# BOONTON

BOONTON ELECTRONICS CORPORATION

TEMIC ONLY
FORGE

INSTRUCTION MANUAL

## MODEL 92BD

PROGRAMMABLE R.F. MILLIVOLTMETER

This instruction manual applies to instruments
with serial numbers 2891 and above.

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INSTRUCTION MANUAL

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**BOONTON**

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# SECTION I

## GENERAL INFORMATION

### 1-1. SAFETY NOTICE

The Model 92BD is furnished with a three-conductor power cable and three-prong plug so that, when the plug is inserted in a properly polarized a.c. power receptacle, the instrument is grounded. The instrument depends upon such connection to ground for equipment and operator safety.

*** * * WARNING * * ***

To avoid the possibility of electrical shock, before anything is connected to this instrument, and before you use this instrument, make certain that its power cable is plugged into a mating a.c. receptacle that has a grounded ("earthed") contact.

Never defeat the instrument's protective grounding. For example: Do not use an extension power cable if it is not equipped with a ground conductor; do not plug the instrument into an a.c. receptacle that does not provide a high-quality earth ground. If only a two-terminal a.c. power receptacle is available, use a three-prong-to-two-prong adapter and connect the ground wire of the adapter to the power-receptacle ground. Do not use such an adapter if the ground wire cannot be grounded.

### 1-2. DESCRIPTION

A. General. The 92BD R.F. Millivoltmeter provides a digital read-out of measurements from the low radio frequencies to the gigahertz region, over a voltage range of 200 µV to 3 volts.* It is a programmable, solid-state instrument of high sensitivity and accuracy, characterized by high input impedance (see Figures 1-1 and 1-2), excellent stability, and low noise.

The 92BD exhibits true r.m.s. response for input signals up to 30 millivolts, gradually approaching peak-to-peak above this level.† The digital voltmeter, however, is calibrated in r.m.s. above this region. A small edgewise panel meter, calibrated in dBm, is included; this is necessary for zeroing the instrument (the digital display blanks out below 200 µV), and will serve also for comparative measurements of acceptable accuracy.

A binary coded decimal (BCD) output is provided at a rear connector, permitting the 92BD to be integrated in systems for driving printers, tape or card punches, data control units, and similar interfacing data equipment. When used as part of a system, the 92BD can be programmed and controlled externally as needed. A linear d.c. output, the level of which is proportional to the r.f. input voltage, is also provided at a rear connector. This d.c. output may be used to drive a recorder, a remote indicator, or other analog devices.

The instrument is sensitive, accurate, sturdily constructed, and protected against overloads. It will perform over extended periods of time without failure or need for recalibration. It is packaged as a compact bench instrument that can be mounted easily in a standard 19-inch rack, using an optional rack-mounting kit.

---

*To 300 V, up to 700 MHz, with accessory 100:1 divider.
†To 3 V, up to 700 MHz, with accessory 100:1 divider.

§1-2, Continued.

B. Frequency Capability. The calibrated frequency range of the 92BD extends from 10 kHz to 1.2 GHz, with uncalibrated response to beyond 8 GHz. Relative accuracy* above 1.2 GHz is typically ± 0.5 dB.

A 50 Ohm BNC Adapter is supplied as a standard accessory with the instrument for 50 ohm voltage measurements up to 600 MHz. A correction curve, Figure 2-2, is included for frequencies above 50 MHz. For higher-frequency measurements and for through-line voltage measurements, the optional Tee Adapter accessory is recommended. It is designed to compensate for the r.f. probe's capacitance and to present a good s.w.r. (better than 1.15) up to 1.2 GHz. It may be used in conjunction with the 50 Ohm Load for terminated voltage measurements. In a coaxial line its insertion loss is low; however, a graph (Figure 2-3) is supplied, showing loss vs. frequency. See Figure 1-4 for typical s.w.r.

C. Voltage Capability. The voltmeter has eight ranges, from 1 mV, f.s., to 3 V, f.s., arranged in a 1-3-10 sequence. No attenuator attachments are required for measurements up to 3 V. While this range is ample for most radio-frequency voltage measurements, the capability of the instrument can be increased to 300 V (up to 700 MHz), by using an optional accessory, the high-impedance 100:1 Voltage Divider. Its use also increases the input resistance by a factor of 1000 to 3000, depending upon the input level.

D. True R.M.S. Response. The Model 92BD provides true r.m.s. response for signal inputs below approximately 30 mV (below 3 V, up to 700 MHz, with the 100:1 Voltage Divider). As the input level increases, the response gradually approaches peak-to-peak, calibrated on the indicator in r.m.s.

E. Low Noise. The Model 92BD has been designed and constructed to hold noise from all sources to a minimum. The probe cable is of special low-noise design; a vigorous flexing causes only momentary, minor deflections of the meter on the most-sensitive range. The probe itself is insensitive to shock or to vibration.

Amplification takes place at 94 Hz, reducing susceptibility to any 50 or 60 Hz line-frequency-related fields. The input signals from the probe are converted into 94 Hz signals by a solid-state chopper.

F. Minimal Zero Adjustment. Zero adjustment is not required on the upper five sensitivity ranges of the voltmeter. For measurements on the lower three ranges, the ZERO control is adjusted on the most sensitive range before operation. Only infrequent checking will be required during the course of subsequent measurements.

G. Outputs. The Model 92BD provides a linear d.c. output whose current capability of 1 mA into 1000 ohms is extremely stable. When used as part of an automatic test system, the fast response of the instrument's d.c. output to an input step-function allows many tests per unit time.

The 92BD also provides a serialized BCD output (4-line, 8-4-2-1), for connection to an external system. When the 92BD is an integral part of a system configuration, it can be remotely controlled and triggered automatically in synchronism with some system event.

For system or external requirements, all input and output connections for the 92BD are made at the card-edge connector at the rear of the instrument. (See §2-10 for receptacle connections.)

---

*Relative accuracy refers to the differential between two measured levels without regard to the absolute accuracy of either measurement. A measurement of a 100 mV signal at 8 GHz may indicate 20 mV on the meter; then a 50 mV signal, at that same frequency, will be indicated as 10 mV, within about 0.5 dB (5.9%).

## 1-3. ACCESSORIES FURNISHED

A. Model 91-12F, R.F. Probe. Probe with low-noise cable and connector assembly for measurements from 10 kHz to 1.2 GHz; see Figures 1-1 and 1-2 for input resistance and capacitance.

B. Model 91-13B, Probe Tip. Removable probe tip with grounding-clip lead; for use up to approximately 100 MHz.

C. Model 91-8B, 50 Ω BNC Adapter (F). Used for measurements up to 600 MHz in a 50 Ω system; for s.w.r., see curve of Figure 1-3.

## 1-4. ACCESSORIES AVAILABLE

A. Model 91-4C, R.F. Probe. Low-frequency probe for measurements ranging from 1 kHz to 250 MHz; input resistance is essentially the same as that of the standard 91-12F R.F. Probe.

B. Model 91-6C, Unterminated BNC Adapter (F). For coaxial connection up to about 100 MHz, or to 400 MHz when fed from a 50 Ω source in an electrically short system.

C. Model 91-7C, 100:1 Voltage Divider. Attenuates the input signal by a factor of 100 ± (1 + $f_{MHz}/200$)%, permitting measurements up to 300 volts and extending the r.m.s. measuring range to 3 volts; increases the input resistance by a factor of 1000 to 3000, depending upon input level; operates from 50 kHz to 700 MHz. Maximum input potential, 1000 volts, d.c. plus peak a.c.

D. Model 91-8B/1, 75 Ω BNC Adapter (F). Used for measurements up to 600 MHz in a 75 Ω system.

E. Model 91-14A, 50 Ω Type-N Tee Adapter (F-F). With 91-15A Termination (see below), permits connection into a 50 Ω line. Required for measurements above approximately 100 MHz. For s.w.r., see Figure 1-4.

F. Model 91-14A/1, 75 Ω Type-N Tee Adapter (F-F). With Model 91-15A/1 Termination (see below), permits connection into a 75 Ω line. Required for measurements above approximately 100 MHz.

G. Model 91-15A, 50 Ω Type-N Termination (M). For use with Model 91-14A Tee connector.

H. Model 91-15A/1, 75 Ω Type-N Termination (M). For use with 91-14A/1 Tee connector.

I. Model 91-16A, Unterminated Type-N Adapter (F). Usable with all probes. Used for coaxial connection up to approximately 100 MHz, or to 400 MHz when fed from a 50 Ω source in an electrically short system.

J. Model 91-18B, Accessory Case. Case for protecting and storing the Model 92BD's accessories.

K. Model 950002, Single Rack-Mounting Kit. Kit for mounting one 92BD as one half of a module in a standard 19-inch rack.

L. Model 950030, Double Rack-Mounting Kit. Kit for mounting two 92BD's side by side in a standard 19-inch rack.

M. Accessory Kit

1. Model 91-24A, Set of Accessories, 50 Ω. Consists of the following abovementioned items: 91-6C, 91-7C, 91-14A, 91-15A, 91-18B.

2. Model 91-24A/1, Set of Accessories, 75 Ω. Consists of these abovementioned items: 91-6C, 91-7C, 91-14A/1, 91-15A/1, 91-18B.

## 1-5. OPTIONS

A. Option -01: Autoranging option; provides for automatic range-switching controlled by the level of the input voltage.
B. Option -08: Rear-Panel Signal Input.
C. Option -09: 50 Ω dBm Display (in addition to mV display).
D. Option -10: 75 Ω dBm Display (75 Ω 91-8B/1 BNC adapter supplied).
E. Option -12: 75 Ω dBmV Display.
F. Option -21: Buffered BCD Series/Parallel Converter.

## 1-6. REQUIRED ACCESSORIES FOR VARIOUS RANGES

To exploit fully the capabilities of the 92BD, the accessories listed in Table 1-1 are required for the indicated ranges of operation.

**Table 1-1. Required Accessories**

| MEASURING RANGE | REQUIRED ACCESSORY | REMARKS |
|---|---|---|
| 100 MHz to 600 MHz | Model 91-8B 50-Ω Adapter for connection to 50 Ω line. Other $Z_O$ available. | Supplied as standard equipment |
| Above 600 MHz | Model 91-14A Tee Connector and 91-15A 50 Ω Termination for connection to 50 Ω line. | Available separately |
| 1 kHz to 250 kHz | Model 91-4C R.F. Probe | Avail. separately |
| Input levels to 300 V; r.m.s. response with levels to 3 V | Model 91-7C 100:1 Voltage Divider; 50 kHz to 700 MHz 50 kHz to 700 MHz | Available separately |

## 1-7. BUS INTERFACE UNIT

The Model 10A-04 adapts the Model 92BD for operation on the IEEE-488-1975 Data Bus.

## 1-8. SPECIFICATIONS

VOLTAGE RANGE: 200 µV to 3 V (300 V up to 700 MHz with accessory 100:1 voltage divider). Lowest detectable voltage is approximately 100 µV.

FULL-SCALE VOLTAGE RANGE: 1, 3, 10, 30, 100, 300, 1000, and 3000 mV.

dBm RANGE: -61 to +23 dBm (+63 dBm up to 700 MHz with optional accessory, 100:1 Voltage Divider).

FREQUENCY RANGE: 10 kHz to 1.2 GHz (uncalibrated response to approximately 8 GHz).

MAXIMUM A.C. INPUT: 10 V, all frequencies and ranges

MAXIMUM D.C. INPUT: 400 V, all ranges

OVERLOAD RECOVERY: Recovers to within 10% of final indication in 1 min. after removal of 3 V (r.m.s), 15 sec. overload on 1 mV range.

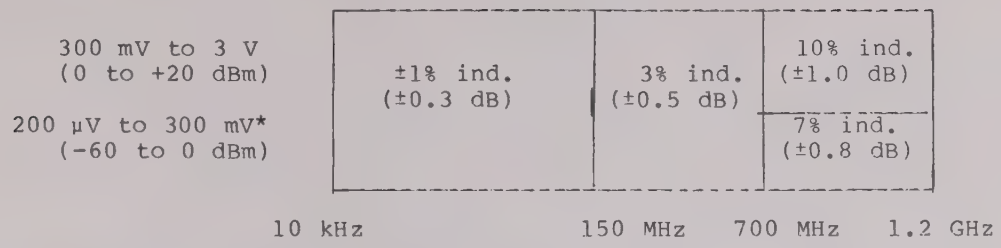
INDICATORS:

Digital: LED, f.s. counts of 3000 and 1000. Full four-digit display with dB option, 0.01 dB resolution. Blanks at 5% over f.s. & at 20% below f.s. Decimal point, annunciators for units and for dB polarity.

Analog: Miniature edgewise type, calibrated -9 to +3 dBm, 50 Ω.

§1-8, Continued.

ACCURACY (at reference conditions): 1% f.s., plus:




dB specifications in parentheses apply to dB options only, and replace the ±1% f.s. & percentage-of-indication specifications.
*Below 1 mV, add 1% f.s.

STABILITY:

Reference conditions
Line Voltage: 115 V - 120 V
Line Frequency: 50 Hz - 400 Hz
Warm-Up Time: usable after 5 min.

Line-Voltage Effect: <0.2% ind. for ±10% line-voltage change

Temperature Effect*: In accordance with ANSI (ASA) Spec. 39.7

| Temperature Range | | Effect: Instrument | Effect: R.F. Probe |
|---|---|---|---|
| Ref. | 21°C to 25°C | 0 | 0 |
| Normal | 18°C to 30°C | 0 | ±1% ind. |
| Severe | 10°C to 40°C | ±1% ind. | ±4% ind. |

* At 1MHz.

Indicator Unrest (1 mV f.s. range only):

| Indicated Voltage | Unrest |
|---|---|
| >600 µV | ±1% f.s. |
| 300 µV to 600 µV | ±2% f.s. |
| >300 µV | ±5% f.s. |

RESPONSE TIME: Less than 100 ms at recorder output on 30 mV to 3 V f.s. ranges, increasing to 1 s on 1 mV range, for f.s. input step function.

DISPLAY UPDATE TIME: 200 ms

R.F.I.: There is no detectable radiated or conducted leakage from the instrument or the probe.

POWER SENSITIVITY: 800 pW, minimum measurable power in 50 ohms. Minimum detectable power in 50 ohms is 200 pW.

WAVEFORM RESPONSE: True r.m.s. response for input levels up to 30 mV (3 volts to 700 MHz using the 100:1 Voltage Divider), with transition to peak-to-peak (calibrated in r.m.s.) at higher levels.

CREST FACTOR: 420 to 1.4, depending upon input level (see Table 1-2).

§1-8, Continued.

| | |
|---|---|
| INPUT IMPEDANCE: | See Figures 1-1 and 1-2. |
| S.W.R.: | Less than 1.20 to 1.2 GHz (return Loss greater than 23 dB). |
| OUTPUTS: | |
| Analog | 0 to 10 V, d.c., proportional to r.f. input voltage as follows:<br>+10 V f.s. on "10" ranges;<br>+9.5 V f.s. on "3" ranges (+10 V for 3.16);<br>linear above 20% f.s. to ±1% f.s.<br>Source resistance: 9 kΩ. |
| Digital | TTL-level 1-2-4-8 BCD data, serial by digits. 1-2-4-8 range information. Overrange, underrange, encode complete. |
| INPUT COMMANDS: | TTL-level inputs select input ranges, mV, dBm and autoranges (option); encode hold, encode trigger, manual disable. |
| POWER: | 115 or 230 V, ± 10%, 50 to 400 Hz, 15 W. |

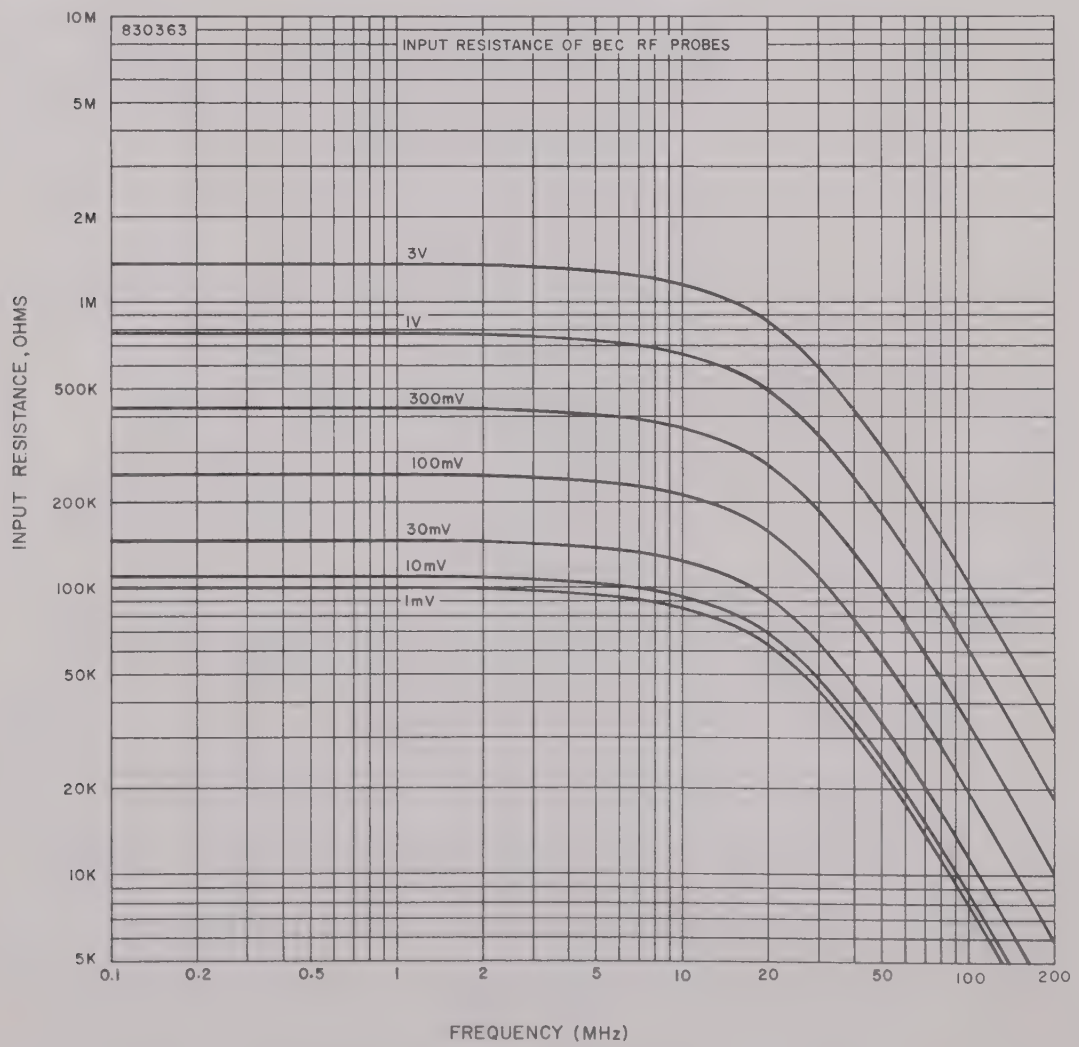



Figure 1-1. Input Resistance of 91-12F R.F. Probe as a Function of Input Level and Frequency

§1-8, Continued.

DIMENSIONS: 132 mm high (without rubber feet) × 211 wide × 292 deep (5.2 in. × 8.3 × 11.5).

WEIGHT:

| | |
|---|---|
| Net | 4.4 kg (9.2 lb) |
| Shipping | 5.2 kg (11.5 lb) |

Table 1-2. Crest Factors

| VOLTAGE RANGES (mV) | 1 | 3 | 10 | 30 | 100* | 300* | 1000* | 3000* |
|---|---|---|---|---|---|---|---|---|
| CREST FACTOR† | 420 to 42 | 70 to 14 | 21 to 4.2 | 7 to 1.4 | 420 to 42 | 70 to 14 | 21 to 4.2 | 7 to 1.4 |

*With accessory 100:1 Voltage Divider.
†Maximum permissible ratio of peak-to-r.m.s value of voltage.

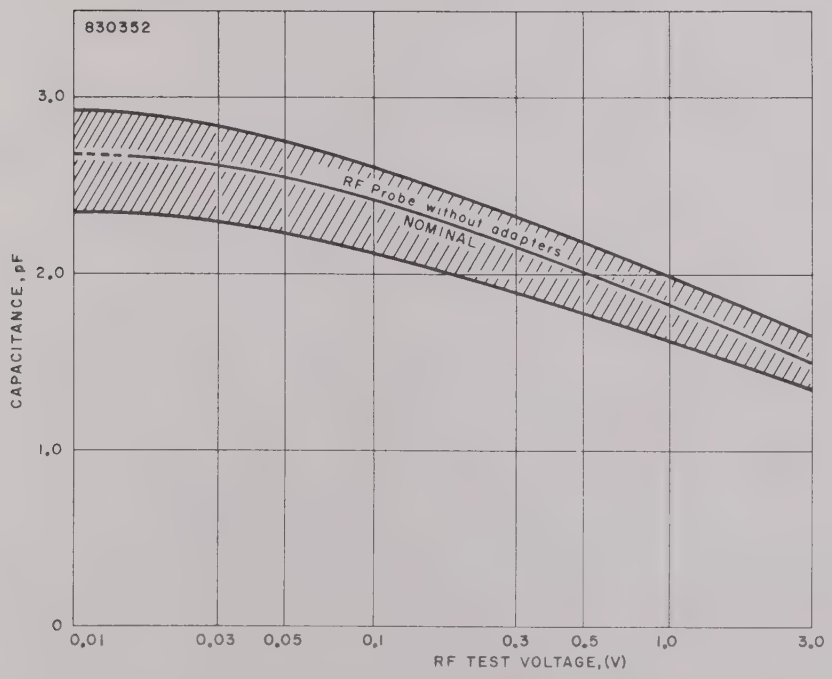



Figure 1-2. Input Capacitance vs Input Level of 91-12F R.F. Probe (Measured at 10 MHz)

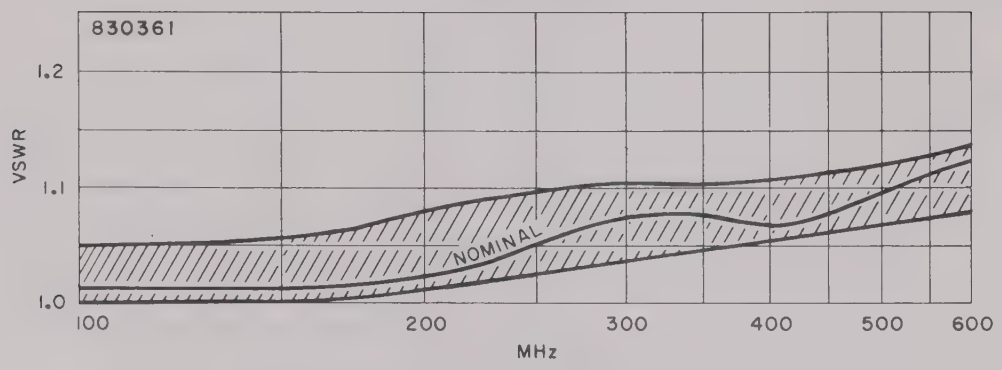



Figure 1-3. Typical S.W.R. of 91-12F R.F. Probe with Model 92-8B 50 Ω Adapter

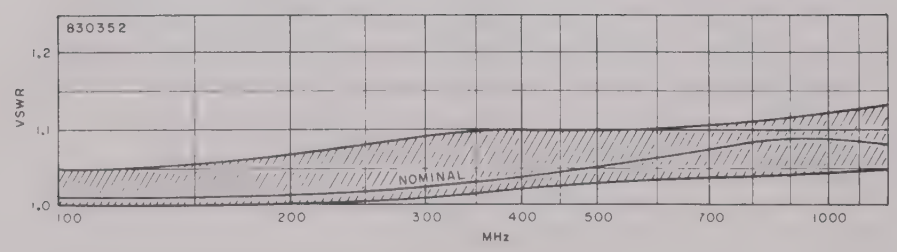



Figure 1-4. Typical S.W.R. of 91-12F R.F. Probe with Model 91-14A Type-N Tee Adapter and Model 91-15A 50 Ω Termination

# SECTION II

## INSTALLATION & OPERATION

### 2-1. INSTALLATION

The 92BD has been inspected and tested at the Factory before packing, and it is shipped ready for operation. If there is any indication of shipping damage, immediately notify the carrier before you attempt to put the voltmeter into operation.

### 2-2. OPERATING CONTROLS AND INDICATORS

All controls, indicators and connectors used during operation of the 92BD are described in Table 2-1, below.

**Table 2-1. Operating Controls, Indicators, and Connectors**

| ITEM | FUNCTION |
|---|---|
| Selector Switch | Turns "on" instrument power; if dB options are installed, selects mV or dBm readout. |
| FULL SCALE Pushbuttons | Select operating range (mV or dBm). The AUTO pushbutton, with -01 option installed, switches 92BD to automatic ranging mode. |
| Indicators | Digital (LED): four digits, decimal point, units, and, with dB options installed, polarity for dBm. Analog: meter, calibrated -9 to +3 dBm, 50 Ω. |
| PROBE Jack | The probe cable connects to the 92BD through this jack. Always check that the knurled ferrule nut of the probe-cable connection is tightened. |
| ZERO Control | This control is used to "zero" the 92BD. |
| Fuse Holder (Rear Panel) | The fuse holder should have installed in it one of the following MDL SLO-BLO fuses: for 115 V, 0.20 A; for 220 V, 0.10 A. |
| Slide Switch (Rear Panel) | Switch is to be set to 115 or 230 V, according to the available line voltage. (Be sure that the proper fuse is installed in the fuse holder.) |
| Recorder Output (Rear Panel) | A d.c. voltage proportional to the meter reading is available at these terminals. |
| REMOTE CONNECTIONS (Rear Panel) | The card-edge plug is intended for use with an Amphenol 225-22221-101 connector, or equivalent. See Table 2-3 for pin designations |

## 2-3. SAFETY REQUIREMENT SYMBOL

This safety requirement symbol (on the rear panel) has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that an instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

## 2-4. INITIAL OPERATING PROCEDURES

A. Be sure that the serial number of the probe to be used is the same as that of the voltmeter. (Each instrument is calibrated for its particular r.f. probe.) Use of a probe other than that for which the instrument was calibrated may result in measurement errors.

B. Connect the probe cable to the PROBE jack on the front panel.

C. Check the setting of the power switch on the rear panel to be sure that it is set to the proper position for the line voltage in use.

D. Plug the instrument's power cable into a power receptacle and turn the selector switch to mV. Allow a minute for the 92BD to warm up.

E. Press the 1 mV range pushbutton; the panel-meter pointer should rest on zero. If it does not, use the ZERO control to set the meter to zero. (This adjustment will hold for the other ranges.) The instrument is now ready for use. (See §2-5E.)

## 2-5. OPERATING NOTES

While using the Model 92BD is a direct and straight-forward process, there are certain precautions and procedures which MUST be observed in order to obtain satisfactory results.

A. Overload Limits. The R.F. Probe supplied with the 92BD is overload-protected to 10 V, a.c., and to 400 volts, d.c. EXCEEDING THESE LIMITS MAY RESULT IN PERMANENT DAMAGE TO THE PROBE.

The 50 ohm adapter should not be subjected to continuous overload of more than 3 volts [d.c. + (a.c., r.m.s.)], to avoid excessive heating of the terminating resistor.

Where voltages above these limits are likely to be encountered, the 100:1 Voltage Divider is required. Maximum rating of the Voltage Divider is 1000 volts, d.c. + peak a.c.

B. Connection for Measurements below 100 MHz. The R.F. Probe supplied with the 92BD is equipped with a detachable tip and ground lead. For signal measurements below approximately 100 MHz, this tip provides a convenient means for both signal and ground connection.

C. Connection for Measurements above 100 MHz. For frequencies above 100 MHz, the probe tip should NOT be used with the 92BD. Connection should be made directly to the probe's center contact, with the ground connection kept as short as possible (preferably to the threaded portion of the body).

The connection recommendations outlined in Table 2-2 should be followed in order to maintain the specified accuracy.

Table 2-2. Connection Recommendations

| FREQUENCY | SIGNAL CONNECTION |
|---|---|
| Up to 100 MHz | Probe with tip and ground lead (supplied). |
| 100 to 250 MHz | Probe without tip, or probe with 50 Ω Adapter (supplied).<br>Probe with Tee Adapter (optional). |
| 250 to 600 MHz | Probe with 50 Ω Adapter (supplied).<br>Probe with Tee Adapter (optional). |
| 600 MHz to 1.2 GHz | Probe with Tee Adapter & 50 Ω Termination (both optional); see Figure 2-1 |

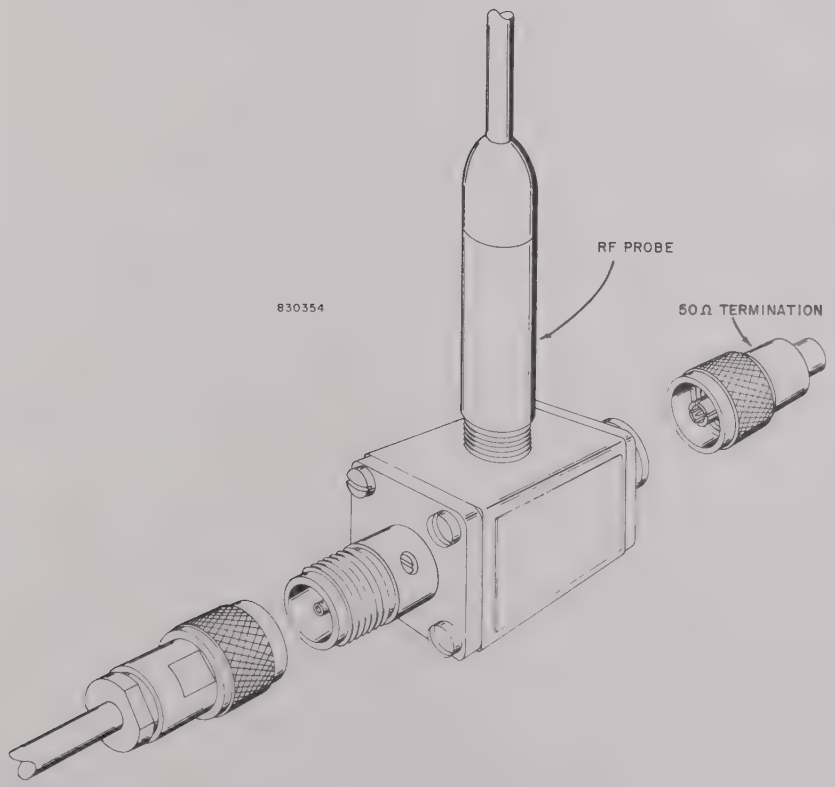



Figure 2-1. Assembly of Type-N Tee Adapter

D. Low-Level Measurement. The voltmeter will provide reliable, reproducible measurements of signal levels as low as 200 microvolts.

Preliminary zero adjustment is essential when using the lowest-range scale to achieve the specified accuracy, and it is strongly recommended for all ranges up to 30 mV.

E. Making the Zero Adjustment. When the instrument is to be used on the 1 mV range, the following zero adjustment procedure should be followed.

1. Set the FULL SCALE range selector to the 1 mV position.

2. Be sure that no voltage is applied to the probe, and that it is adequately shielded from local fields. This can be done by partially unscrewing the probe cap until the tip just breaks contact with the internal connector, leaving the metal shell engaged with the body threads. Alternatively, you can remove the probe tip and mount the 50 ohm termination in its place.

3. Adjust the ZERO control to bring the meter reading to zero. Noise may cause the reading to fluctuate. If so, adjust the ZERO control so that the reading averages zero.

F. Signal Overload on 1 mV Range. On the most sensitive (1 mV) range, the application of a large a.c. signal overloads the amplifier and a short time is required for the high-impedance input circuit to discharge. This effect is significant for signals above approximately 100 millivolts. Typically, application of a 1 volt signal will require a recovery time of about thirty seconds before subsequent measurements should be made on the 1-mV range. It should be noted, however, that such overloads cause no damage to the equipment as long as they are within the limits outlined in §2-5A.

G. Temperature Effects. The accuracy specifications for the 92BD apply over temperatures from 50°F to 104°F. Outside of these limits operation of the equipment is possible but appreciable inaccuracies can be expected. However, no permanent change in probe characteristics will result from any reasonable high- or low-temperature exposure.

Note that inaccuracies of measurement resulting from temperature effects may occur shortly after soldering to the probe tip, or measuring with the probe in the vicinity of heat sources such as resistors, heat sinks, vacuum tubes, and so forth.

When making low-level measurements (below approximately 2 millivolts) it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and the outside of the probe can generate a small thermal voltage that may add to the d.c. output of the detector diodes.

H. Hum, Noise and Spurious Pick-up. When measuring low-level signals, precautions should always be taken to avoid the possibility of errors of measurement resulting from hum, noise or stray r.f. pick-up. Although all low-frequency hum and noise are attenuated at the input, it is still possible for unwanted high-level signals to cause errors. In some cases it may be necessary to provide extra shielding around the probe connections to reduce stray pick-up. Typical sources of spurious radiation are: induction or dielectric heating units, diathermy machines, local radio transmitters, and "Dip" meters.

I. Over- and Under-Range Indications. When the r.f. voltage applied to the probe is approximately 5% above the maximum, or 12% below the minimum, of the range in use, the digital indicator will blank out. In that case, switch to the next appropriate range.

## 2-6. D.C. OUTPUT

The d.c. output provided at the rear-panel binding posts is a linear function (typically within 1%) of the input level, as long as the input signal is greater than 20% of full scale. The polarity of the d.c. output is positive with respect to the instrument ground, the negative d.c. output terminal being at ground potential. The output resistance is 9 kΩ.

## 2-7. LOW-FREQUENCY MEASUREMENTS

The R.F. Probe supplied with the 92BD provides measurements within the specified accuracy from 10 kHz to 1.2 GHz. For measurements at lower frequencies a Low-Frequency R.F. Probe is available. It operates over a range of frequencies from 1 kHz to 250 MHz. NOTE: After installing this probe, the 92BD MUST BE checked for accuracy of calibration. The voltmeter must be recalibrated, if it is required. (See §4-4 and §4-5.)

## 2-8. CORRECTION CURVE FOR 50 Ω ADAPTER

When using the 50 Ω BNC Adapter at frequencies between 50 MHz and 600 MHz, increase the measured voltage by the percentage shown in Figure 2-2.

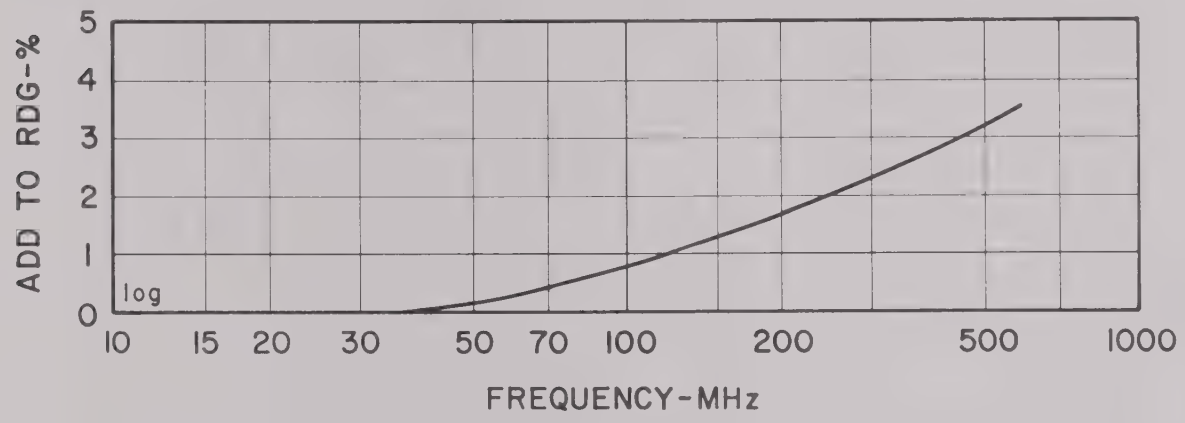



Figure 2-2. Model 91-8B 50 Ω BNC Adapter, Correction Curve

## 2-9. CORRECTION CURVE FOR TEE ADAPTER

Use Figure 2-3 to make corrections for transmission loss when using the Type-N Tee Adapter. The meter reads the voltage applied to the Tee's input port. The loss in dB between input and output ports is given in Figure 2-3. Subtract the correction from the meter's indicated value, in dB, to obtain the output voltage of the tee. Example: At 850 MHz, the output level is 1 dB less than the input level, which is indicated on the meter.

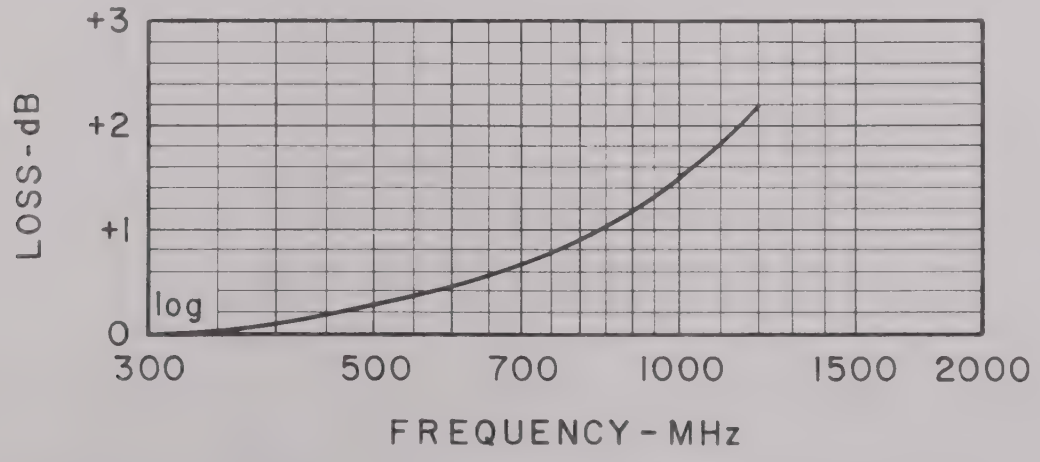



Figure 2-3. Model 91-14A Type-N Tee Adapter, Correction Curve

## 2.10 INTERFACE OPERATION

Remote programming is accomplished by simultaneously shorting to common the Manual Disable and the appropriate range lines on the card-edge connector located at the rear of the 92BD. When the Manual Disable is brought to common (i.e., pin 5), the front-panel switches in effect are disconnected. Figure 2-4 is a pictorial diagram of the rear-panel programming inputs and data output connections. Tables 2-3 through 2-6 provide additional data on these connections.

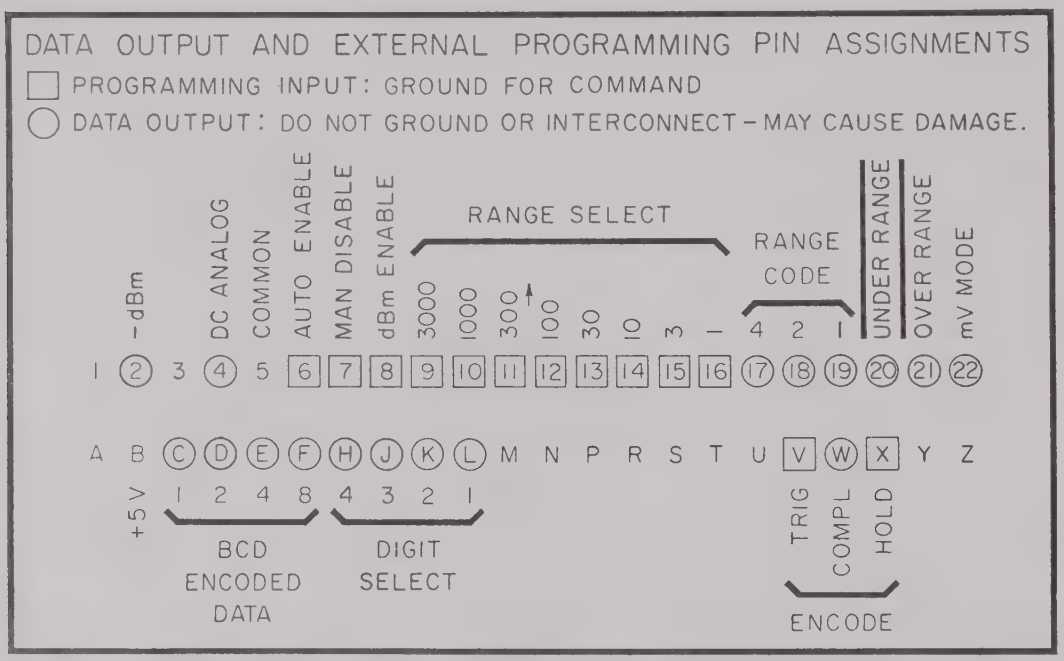



**Figure 2-4. Rear-Panel Pin Assignments**

A. Programming Inputs.

**Table 2-3. Rear-Panel Pins: Programming Inputs**

| Pin No. | Function | Comment | Command | Unit Loading |
|---|---|---|---|---|
| 7 | Man.Disable | Disables front-panel range selection | 0 | 0.1 |
| 8 | dBm Enable | Selects dBm display* | 0 | 0.1 |
| 6 | Auto Enable | Selects automatic ranging* *With Manual Disable also selected | 0 | 0.1 |
| 16 | 1 mV range | Selects range, provided that Manual | 0 | 0.1 |
| 15 | 3 mV " | Disable has also been selected. | 0 | 0.1 |
| 14 | 10 mV " | Selecting more than one range will | 0 | 0.1 |
| 13 | 30 mV " | result in incorrect indications. | 0 | 0.1 |
| 12 | 100 mV " | Range lines must be de-selected for | 0 | 0.1 |
| 11 | 300 mV " | manual operation. | 0 | 0.1 |
| 10 | 1 V " | | 0 | 0.1 |
| 9 | 3 V " | | 0 | 0.1 |
| X | Encode Hold | Holds display | 0 | 0.2 |
| V | Encode Trigger | Starts "encode" cycle | see §2-10D | 0.1 |

§2-10, Continued.

B. Input Characteristics. Interface input characteristics are given in Table 2-4.

**Table 2-4. Interface Input Characteristics**

| TTL Series | Logic Level | Voltage Level | Curent per Unit Load |
|---|---|---|---|
| Standard Power 54/74 | 0 | ≤ 0.7 V | -1.6 mA* |
| | 1 | 2.4 to 5.25 V | 40 µA |

*The "-" current indicates current out of the input (the external command device must sink this current). A standard power (Series 54/74) TTL output will sink and source 10 unit loads.

C. Input Pull-Up. All input terminals have internal pull-up. The current sourced by this pull-up when the input is brought to a logic-level 0 is included in the loading shown in the "Unit Loading" column of Table 2-3.

D. Triggering. To trigger an "encode" cycle, the trigger line must be transferred from logic "1" to logic "0". The limits for trigger-pulse characteristics are shown in Figure 2-5.

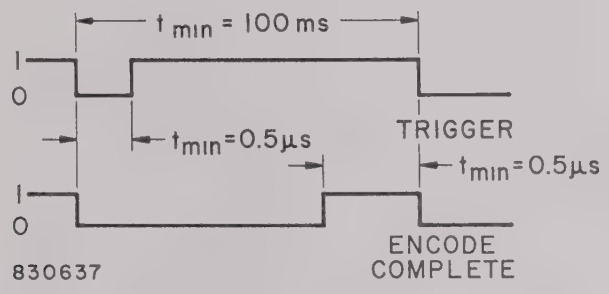



**Figure 2-5. Encode-Trigger Timing Graph**

E. Output Characteristics. Interface output characteristics are given in Table 2-5.

**Table 2-5. Interface Output Characteristics**

| TTL Series | Logic Level | Voltage Level | Curent per Unit Load |
|---|---|---|---|
| Standard Power 54/74 | 0 | ≤ 0.7 V | 1.6 mA |
| | 1 | 2.4 to 5.25 V | -40 µA* |

*The "-" current indicates current sourced by the output.

F. D.C. Analog Output.

1. Polarity: positive with respect to instrument ground. (The negative D.C. Analog Output terminal is at ground potential.)

2. Source Resistance: 9 kΩ.

G. Data Outputs.

**Table 2-6. Rear-Panel Pins: Data Outputs**

| Pin No. | Function | Comment | True-Logic Level | 54/74 Unit Loading |
|---|---|---|---|---|
| 22 | mV mode | Indicates voltage display | 1 | 1 |
| 4 | D.C. Analog | 10 V for f.s. on "1" ranges; 9.5 V for f.s. on "3" ranges | N.A. | N.A. |
| 21 | Overrange | Indicates that 92BD's range should be increased | 0 | 1 |
| 20 | Underrange | Indicates that 92BD's range should be decreased | 0 | 1 |
| 2 | -dBm | Indicates that dBm is below the reference level | 1 | 1 |
| W | Encode Complete | Indicates completion of the encode cycle; data output may be read. | 1 | 1 |
| 17 | 4 | Indicates range selected, in binary code. 0 = 1 mV range, 7 = 3000 mV range. | 1 | 1 |
| 18 | 2 Range Code | | | |
| 19 | 1 | | | |
| F | 8 | Data in serial form, continulously scanned, left (MSD) to right, 500 µs per digit, 2 ms scan. | 1 | 1 |
| E | 4 BCD Encoded | | 1 | 1 |
| D | 2 Data | | 1 | 1 |
| C | 1 | | 1 | 1 |
| H | 4 | Indicates digit to which BCD data applies. 4 = MSD (left-most) | 1 | 1 |
| J | 3 Digit Select | | 1 | 1 |
| K | 2 | | 1 | 1 |
| L | 1 | | 1 | 1 |

H. Autoranging Characteristics. The 92BD up-ranges at approximately 107% of full scale; it down-ranges at approximately 28% of full scale.

I. Data Output Timing. See Figure 2-6, below.

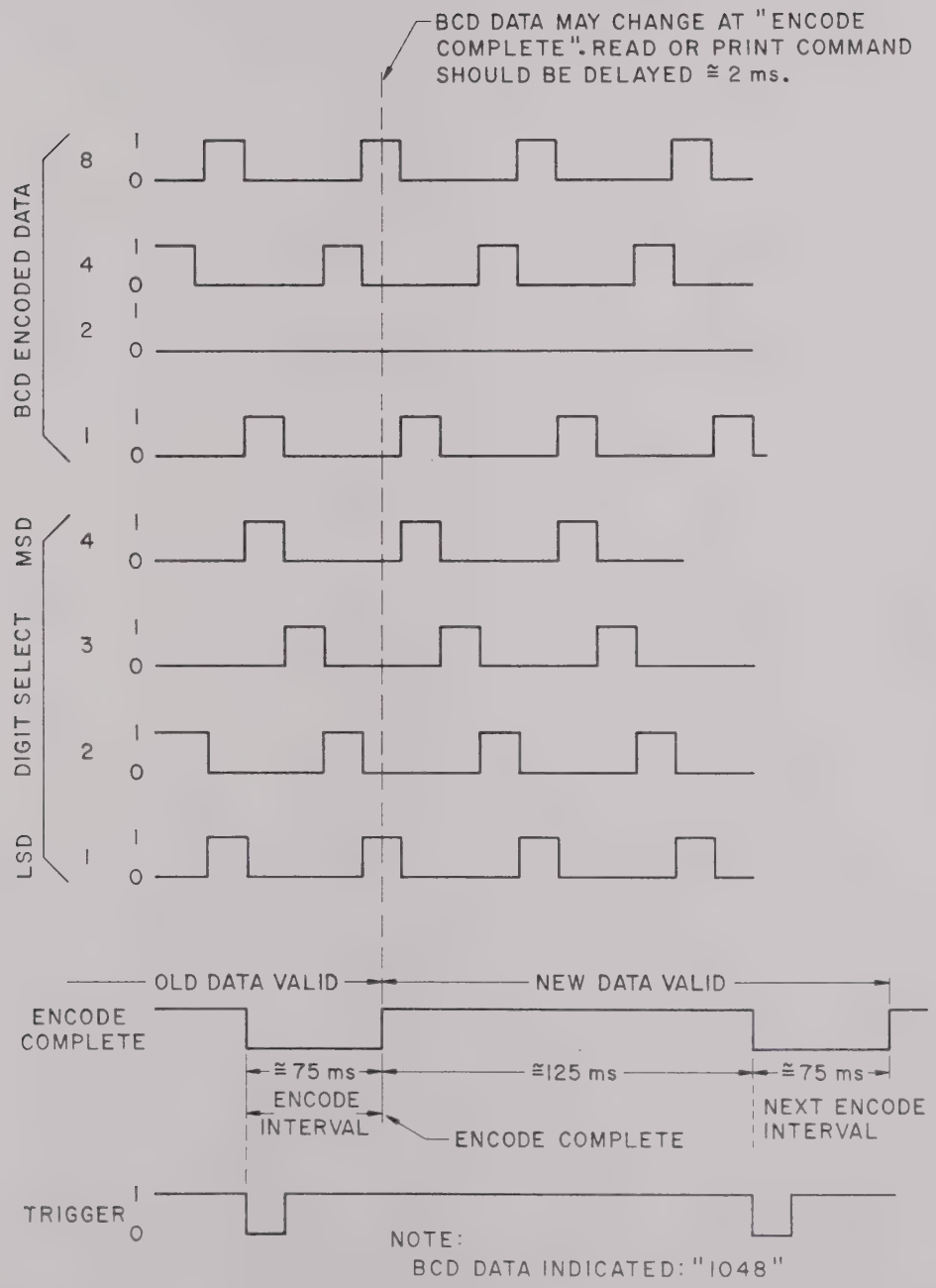



**Figure 2-6. Data-Output Timing Graph**

# SECTION III

## THEORY OF OPERATION

### 3-1. INTRODUCTION

For this discussion, refer to Figure 3-1, a block diagram of the 92BD. The essential elements of the instrument are: probe, chopper, pulse generator, demodulator, shaping amplifier, digital control, analog-to-digital (A-D) converter, digital display, panel meter, and power supply.

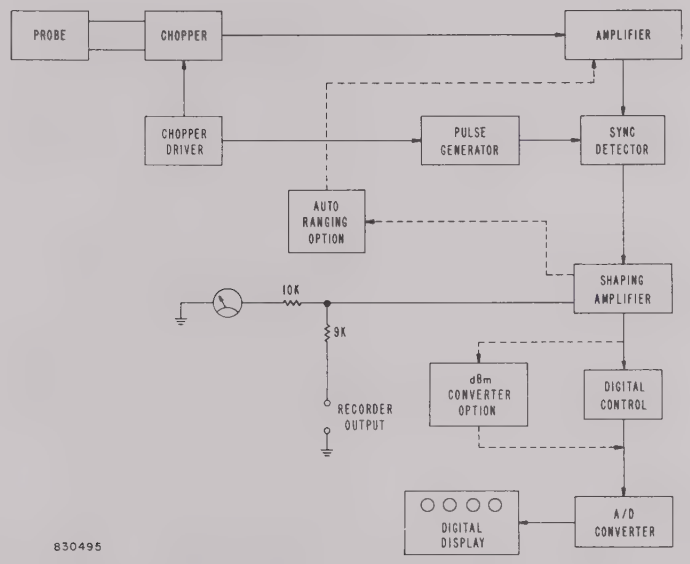



**Figure 3-1. Model 92BD Block Diagram**

### 3-2. R.F. PROBE

The R.F. Probe embodies a full-wave diode detector, which rectifies the signal under study to a d.c. voltage whose level is a function of the input level. While operating in the square-law region (below approximately 30 millivolts), the detector provides true r.m.s. response. As the input increases beyond 30 mV, waveform response gradually approaches peak-to-peak, calibrated on the indicator in r.m.s.

In addition to increasing efficiency, use of full-wave rectification in the detector probe permits measurement of signals having highly asymmetrical waveforms without errors stemming from turn-over effect.

The diodes used in the R.F. Probe have been carefully selected for specific characteristics. The user is urged NOT to attempt their replacement with any off-the-shelf types. In case of damage to probe components, call your local Boonton Electronics Sales Engineering Representative, or the factory, for instructions.

### 3-3. CHOPPER

The chopper board contains four solid-state switches, which are used to convert input d.c. voltage to a 94 Hz square wave. The switches are controlled by 94-Hz chopper-drive signals supplied from a frequency-divider chain in the analog section. Potentiometers A4R4 and A4R5 provide means

for adjusting the chopper so that it has zero output with zero input. Use of a solid-state chopper eliminates most of the undesirable characteristics of electro-mechanical choppers (for example: contact wear, bounce, and contamination). The output of the chopper is a balanced 94 Hz square wave that is directly proportional to the d.c. voltage applied from the sensor.

### 3-4. AMPLIFIER

The balanced 94 Hz square-wave signal from the chopper is amplified by the operational amplifiers A2U3, A2U4, A2U6 and A2U8. The gain of the op amps A2U3, A2U4 and A2U6 is controlled by adjusting feedback to the amplifier through the multiplexer A2U2 and a resistor network. The signals from the ranging section, applied through gates A2U7a and A2U7b, control the switching of input terminals D1 and D2 of multiplexer A2U2 to two of eight points in the resistance networks, thereby adjusting the feedback and the gain of the amplifier.

The 94 Hz output of op amps A2U3 and A2U4 is applied to the differential inputs of op amp A2U6, which makes the signal single-ended. This signal is amplified by op amp A2U8 and associated circuitry. Multiplexer A2U9 adjusts the gain of this op amp in eight steps, under control of signals from the ranging section, to provided decade ranging in voltage. The nominal output for a full-scale input on each range is about four volts, p-p (at TP2). Separate potentiometers are provided for full-scale calibration of the instrument on each range.

### 3-5. DEMODULATOR

A solid-state demodulator, comprising switches A2U11b and A2U11c, converts the amplified and scaled 94 Hz square-wave signal back to d.c. The demodulator is driven by a 94 Hz demodulator-drive signal, which is synchronized with the 94 Hz chopper-drive signal. A synchronous, sampling demodulator circuit is used, with the sample being taken at a point well removed from the chopper-switching points. The demodulator is followed by the high-input-impedance buffer A2U17 to reduce loading of the sampling capacitor, A2C10, to negligible proportions. Output d.c. is suplied to the shaping section.

### 3-6. SHAPING AMPLIFIER

The conversion of r.f. to d.c. in the probe is non-linear: the response is square-law for the lowest ranges, gradually becoming quasi-linear for the 3 volt range. The shaping amplifier converts the non-linear ouput of the phase detector (§3-5) to a linear output by using a segmental approximation to the exact correction. The shaping amplifier is acutally an op amp so connected that, as the signal increases at its output, its gain is reduced by successively paralleling resistors across the feedback resistors. The number of segments required to linearize the response adequately varies from six for the square-law range down to two for the 3 V range. The output of the shaping amplifier is +10 V, which drives the panel meter and is applied to the recorder terminals through a 9 kΩ resistor.

### 3-7. DIGITAL CONTROL

The analog d.c. signal voltage from the shaping amplifier is processed by the digital control circuits before being passed on to the A-D converter and the digital display. The digital control section divides the incoming voltage (10 V, f.s.) by factors of 20 or 6.3, depending upon which range group has been selected. It extracts information for the control of range, decimal-point position, over- or under-range readings, polarity indicator, and identification (mV or dBm). In instruments with the dB options, this section also contains the additional circuitry to covert the incoming voltage information into dBm values. The processed analog incoming voltage is then passed on the A-D converter section.

### 3-8. ANALOG-DIGITAL CONVERTER

In this dual-slope converter, analog information is changed into digital form and applied to the digital-display unit, where the appropriate segments of the LED display are triggered.

## 3-9. POWER SUPPLY

The power supply converts the a.c. input power to regulated +15 and -15 V outputs. Each supply is protected by current limiting against accidental short circuits. Both supplies are adjustable to 15.0 ± 0.1 V.

## 3-10. PROGRAMMING

The 92BD is organized around an eight-line ranging system. Switching, in each functional sub-circuit, is accomplished by solid-state devices that are actuated by the appropriate range line. The front-panel range switch simply connects to the eight range lines to allow range selection. The range lines are buffered by a logic-level converter. The 92BD can be externally ranged by a logic "0" command on the appropriate range line and the manual-disable line.

# SECTION IV

## MAINTENANCE

### 4-1. INTRODUCTION

Values and tolerances shown in this section are not specifications but are provided only as guides to the maintenance and calibration of the 92BD.

### 4-2. PERIODIC CALIBRATION

The 92BD is designed to be trouble-free over extended periods of time. However, as with any precision instrument, the 92BD should be checked periodically to verify proper calibration. To make such calibration checks, The Boonton Model 26A R.F. Millivoltmeter Calibrator is suggested. The 26A provides the correcxt signal levels required to calibrate full-scale, as well as incremental values on all ranges of the Model 92BD. If a Model 26A is not available, these auxiliary instruments are required:

A. A reliable signal source of 200 kHz - 500 kHz with less than 1% distortion at levels up to 3 volts across 50 ohms. BOONTON 2.6A

B. A precision a.c.v.m. such as the Ballantine 310A or 300H, the Boonton 93A or 93AD, or the Hewlett-Packard 400D or 400H, or equivalent.

The following instruments are also needed: 3455 or EQUIV

C. A digital d.c. voltmeter (DVM) capable of measuring ± 15.00 V, accurate to 0.1% or better, with input impedance > 10 MΩ.

D. An oscilloscope. HP

***** WARNING *****

> Line voltages up to 220 volts, a.c., may be encountered in the power-supply circuits. To protect against electrical shock, observe suitable precautions when connecting and disconnecting test equipment, and when making voltage measurements.

### 4-3. PRECAUTIONS WHEN CHECKING CALIBRATION

When checking the calibration of an instrument having the sensitivity and bandwidth of the Model 92BD, it is essential to take precautions against errors resulting from stray pick-up voltages (see §2-5H). A well shielded signal source must be used in conjunction with coaxial connections to both the 92BD and the standard reference meter. Even with a well shielded generator and connections, it is sometimes possible for the reference meter to pick up stray r.f. signals and feed them into the probe. It is advisable to test for this condition by disconnecting the standard meter and noting any change in level.

### 4-4. CALIBRATION CHECK

Using the equipment listed in §4-2, check the calibration of the 92BD on each range, using a test voltage equal to the full-scale value. If the check reveals that recalibration is required, the procedure outlined in §4-5 should be followed.

### 4-5. CALIBRATION PROCEDURE

The 92BD should be calibrated at room temperature (23°C) after a minimum warm-up time of one hour.

Adjustment #1. Measure the -15.0 V supply voltage at the -15 V test point (located on main amplifier board at C119). Adjust R143 to -15.0 ± 0.1 V.

Adjustment #2. Measure the +15.0 V supply voltage at the +15 V test point (located on main amplifier board at C119). Adjust R140 to +15.0 ± 0.1 V.

Adjustment #3. Depress the 30 mV FULL SCALE range pushbutton. Connect DVM to TP2. With no input to the probe, adjust R28 for 0.00 V d.c. on DVM.

Adjustment #4. With zero input to probe, connect DVM to TP17. Adjust R40 for 0.00 V d.c. on the DVM.

Adjustment #5. Depress the 1 mV FULL SCALE range pushbutton. Connect the DVM to TP17 and note the indication (again, with zero input to the probe). Set the two chopper adjustments, A4R4 and A4R5, to their physical mid-points. Adjust A4R4 to decrease the voltmeter's indication to one-half of the value noted above. Adjust A4R5 to bring the indication to zero. There will be some fluctuation of the indication, and averaging will be required.

Adjustment #6. Depress the 30 mV FULL SCALE range pushbutton, with zero input to the probe. Connect the DVM to the RECORDER terminals on the rear panel of the 92BD. Adjust R40 for 0.00 V d.c. on the DVM.

Adjustment #7. Depress the 1 mV FULL SCALE range pushbutton (with zero input to the probe), and zero the 92BD as described in §2-5E.

Adjustment #8. Depress the 1000 mV FULL SCALE range pushbutton. Connect the DVM to TP17. Apply 1000 mV to the probe. Adjust R29 for a reading of -3.10 V d.c. on the DVM.

Adjustment #9. Move the DVM to the RECORDER terminals; adjust R353 for a reading on the DVM of 10.00 V d.c.

Adjustment #10. Move the DVM to pin 8 of IC606; adjust R645 for a reading on the DVM of 0.500 V d.c.

Adjustment #11. Depress the 3000 mV FULL SCALE range pushbutton and apply an input of 3000 mV to the probe. Move the DVM to the RECORDER terminals, and adjust R363 for a reading of +9.487 V on the DVM.

Adjustment #12. Move the DVM to pin 11 of IC606; adjust R632 for a reading of 1.500 V d.c. on the DVM.

Adjustment #13. Disconnect the DVM. With 3000 mV still applied to the probe, adjust R1405 for a front-panel display of 3.000 V.

Adjustment #14. Depress the 1 mV FULL SCALE range pushbutton (zero 92BD as in §2-5E). Apply an input of 1.000 mV to the probe and adjust R303 for a display of 1.000 mV.

Adjustment #15. Depress the 3 mV FULL SCALE range pushbutton (zero 92BD as in §2-5E). Apply 3.000 mV to the probe; adjust R308 for 3.000 mV display.

Adjustment #16. Depress the 10 mV FULL SCALE range pushbutton (zero 92BD as in §2-5E). Apply 10.00 mV to probe; adjust R318 for 10.00 mV display.

Adjustment #17. Depress the 30 mV FULL SCALE range pushbutton. Apply 30.00 mV to the probe; adjust R318 for 30.00 mV display.

Adjustment #18. Depress the 100 mV FULL SCALE range pushbutton. Apply an input of 100.00 mV to the probe. Adjust R341 for a display of 100.0 mV.

Adjustment #19. Depress the 300 mV FULL SCALE range pushbutton. Apply an input of 300.0 mV to the probe. Adjust R347 for a display of 300.0 mV.

Adjustment #20. (For instruments with Autoranging option only.)
NOTE: This control will not normally require adjustment.
Depress the 1000 mV FULL SCALE range pushbutton and apply an input to the

probe of 1000 mV. Depress the AUTO pushbutton. Increase the input level* slowly, noting the point at which the instrument ranges up to the 3000 mV range. Adjust R716 for a range trip at 1030 ± 10 mV. It will be necessary to repeat this step several times in order to achieve the desired setting.

*These adjustments require a continuously variable r.f. input level, which can best be obtained from a signal generator or oscillator. If the 26A R.F. Millivoltmeter Calibrator is being employed, a low-resistance potentiometer may be connected between the 26A and the r.f. probe. (Absolute power levels and impedance matching are unimportant for these adjustments.)

Adjustment #21. Depress the 300 mV FULL SCALE range pushbutton and apply 224 mV* (0 dBm, 50 Ω) input to the probe; adjust R644 for an indication of 0 dBm on the edge meter.

*For instruments with -10 option, apply 274 mV (0 dBm, 75 Ω).

NOTE: Adjustments 22 through 25 apply only to instruments with dB options.

Adjustment #22. Depress the +20 dBm FULL SCALE range pushbutton and set the rotary selector switch to dBm. Remove the digital control board and mask pins 1, 2, Z, and 22 with tape. Insert the control board in the extender board, then insert the extender board in the 92BD. Apply -6.000 V d.c. ± 0.1% at the junction of R627 and R629. If necessary, adjust R1408 on the digital panel meter board for a display of 6000. Disconnect the input from the junction of R726 and R629.

Adjustment #23. Apply 7.071 V d.c. (8.660 V for 75 Ω dB option) ±0.1% at the junction of R636 and R643. With the rotary selector still set at dBm and the +20 dBm pushbutton still depressed, adjust R614 for a display of +20 dBm.

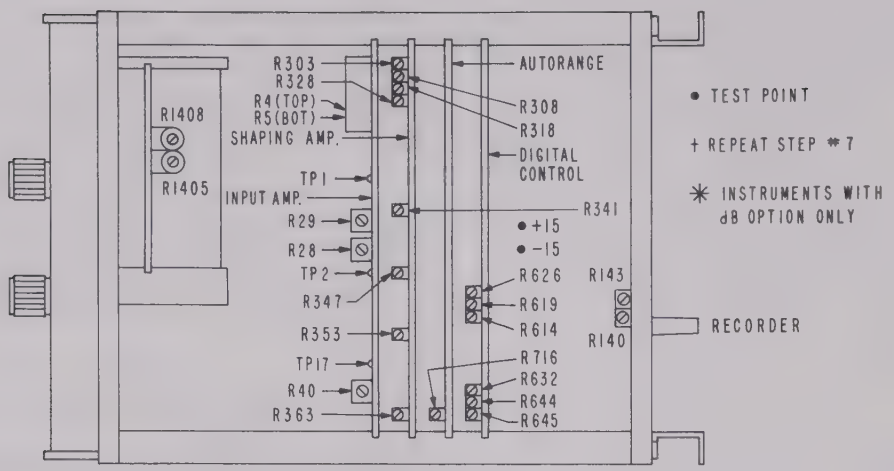
Adjustment #24. Depress the -50 dBm pushbutton and adjust R626 for a display of -50 dBm. There is some interaction in adjustments 23 and 24, so repeat them until both readings are as close as possible to the correct values. However, at this stage it is more important that the two readings show a 70 dB difference.

Depress the 0 dBm pushbutton and adjust R614 for a display of 0.00 dBm. Check each range for the correct reading in dBm, ± 0.1 dB. Touch up R626 to bring in the middle ranges if they are out by more than ± 0.2 dB.

Adjustment #25. Increase the applied d.c. voltage to +10.00 V. Depress the 0 dBm pushbutton and note the display. Decrease the applied d.c. to 3.162 V and note the display. Adjust R619 for a 10 dB difference between the readings. Remove the connection to the junction of R636 and R643. Turn the rotary selector switch to OFF. Remove the extender card, remove the tape from the digital control board, and re-insert the digital control board in the 92BD.

NOTE: Adjustment 26 is required only in the event that IC1202 is replaced.

Adjustment #26. Adjust C1203 for a 50 ms pulse measured at pin 8 of IC1402. If this value cannot be obtained within the range of C1203, try slightly different values of C1202 (up to 200 pF), until the 50 ms pulse is within the range of trimmer C1203.




| ADJ NO | CONT | FUNCTION | RANGE | INPUT ± 0.2 % | ADJUST |
|---|---|---|---|---|---|
| 1 | R143 | −15 V ADJ | − | 0 | −15.0 V ±0.1 V AT −15 V TP |
| 2 | R140 | +15 V ADJ | − | 0 | +15.0 V ±0.1 V AT +15 V TP |
| 3 | R28 | DC ZERO | 30 mV | 0 | 0.00 V ±0.01 V AT TP 2 |
| 4 | R40 | DETECTOR ZERO | 30 mV | 0 | 0.00 V ±0.1 V AT TP 17 |
| 5 | R4 1/2 & R5 1/2 | CHOPPER ZERO | 1 mV | 0 | AVERAGE ZERO INDICATION AT TP17 |
| 6 | R40 | RECORDER ZERO | 30 mV | 0 | 0.00 V ±0.01 V AT RECORDER TERMINALS |
| 7 | R401 | FRONT PANEL ZERO | 1 mV | 0 | AVERAGE ZERO INDICATION AT RECORDER TERMINALS |
| 8 | R29 | OVERALL GAIN | 1000 mV | 1000 mV | −3.10 V AT TP17 |
| 9 | R353 | RANGE ADJ | 1000 mV | 1000 mV | +10.00 V AT RECORDER TERMINALS DC VOLTMETER INPUT > 10 MEGOHMS |
| 10 | R645 | 1 DIVIDER | 1000 mV | 1000 mV | 0.500 V AT PIN 8 OF IC606 |
| 11 | R363 | RANGE ADJ | 3000 mV | 3000 mV | +9.487 V AT RECORDER TERMINALS DC VOLTMETER INPUT > 10 MEGOHMS |
| 12 | R632 | 3 DIVIDER | 3000 mV | 3000 mV | 1.500 V AT PIN 11 OF IC606 |
| 13 | R1405 | + DPM FS ADJ | 3000 mV | 3000 mV | 3000 mV INDICATION |
| 14 † | R303 | RANGE ADJ | 1 mV | 1 mV | 1.000 mV INDICATION |
| 15 † | R308 | RANGE ADJ | 3 mV | 3 mV | 3.000 mV INDICATION |
| 16 † | R318 | RANGE ADJ | 10 mV | 10 mV | 10.00 mV INDICATION |
| 17 | R328 | RANGE ADJ | 30 mV | 30 mV | 30.00 mV INDICATION |
| 18 | R341 | RANGE ADJ | 100 mV | 100 mV | 100.0 mV INDICATION |
| 19 | R347 | RANGE ADJ | 300 mV | 300 mV | 300.0 mV INDICATION |
| 20 | R716 | AUTORANGE TRIP ADJ | AUTO | 1000 − 1100 mV | TRIP TO 3000 mV RANGE AT 1030 mV |
| 21 | R644 | EDGEMETER ADJ | 300 mV<br>300 mV | 224 mV<br>274 mV | ZERO dBm INDICATION ( 50 OHMS REF)<br>ZERO dBm INDICATION ( 75 OHMS REF) |
| 22 | R1408 | − DPM FS ADJ ✳ | 3000 mV | −6.000 Vdc | −60.00 dBm INDICATION |
| 23 | R614 | dB REFERENCE ✳ | 3000 mV<br>3000 mV | 7.071 Vdc<br>8.660 Vdc | ADJUST FOR +20.0 dBm ( 50 OHMS REF)<br>ADJUST FOR +20.0 dBm ( 75 OHMS REF) |
| 24 | R626 | dB RANGING ✳ | −50 dBm | 7.071 Vdc | 70 dB SPREAD BETWEEN +20 AND −50 dBm |
| 25 | R619 | dB LINEARITY ✳ | 0 dBm | 3.162 Vdc | 10 dB SPREAD BETWEEN 0 AND −10 dBm |

831359

Figure 4-1. Adjustment Locations and Descriptions

## 4-6. TROUBLESHOOTING

A. General. If trouble develops in the operation of the 92BD, it is advisable to make a systematic check of the a.c. voltages, d.c. voltages, and resistances. The test points, waveforms, and related test-voltages are shown on the schematic diagrams (see Section VI).

Once the trouble has been found and corrected, the calibration must be rechecked and readjusted as outlined in §4-4 and §4-5.

B. Replacement of R.F. Probes. The 92BD's serial number matches that of the R.F. Probe with which it was calibrated at the factory. If probes are changed for any reason, the instrument's calibration MUST be rechecked. In most cases, full recalibration (see §4-5) will be required. Similarly, if the R.F. Probe supplied with the 92BD is exchanged for a Low-Frequency Probe, recalibration will be required. (See §2-7.)

C. Probe Tests. The probe and accessories furnished with the 92BD can be checked for s.w.r. and frequency response by following the procedures detailed in the paragraphs below. Should a probe exhibit out-of-tolerance performance in these tests, the user is urged not to attempt repair but to send the probe back to the factory for repair or replacement.

1. S.W.R. Measurement.

a. Test Equipment

i. Generator for the desired frequency range. For example:
125 kHz - 175 MHz, Boonton Electronics Model 103D;
450 kHz - 1040 MHz, Boonton Electronics Model 102F-20;
10 MHz - 1400 MHz, Hewlett-Packard Model 8660 A/C

ii. Slotted line: GR Type 900 LB

iii. Detector: GR Type 1241, or Boonton Model 92E.

b. Test Procedure

i. Connect the slotted line to a proper signal source, and terminate the line with the device to be tested, i.e., the Tee Adapter and the 50 Ω Termination, or the 50 Ω Adapter.

The probe and R.F. Millivoltmeter must be connected to the accessory being tested. The probe supplies a perturbation for which the accessory was designed, and which it needs, to meet its specification. The millivoltmeter permits the test level to be set to the desired value.

ii. Move the carriage of the slotted line to a point of minimum voltage, then to a point of maximum voltage, and record the values.

iii. The s.w.r. is the ratio of the maximum and the minimum voltages. The measurement can be repeated at other frequencies and levels, as required.

2. Frequency Response. The most accurate method of measuring the frequency response of the R.F. Probe for the Model 92BD is through the use of micropotentiometers, electrothermic a.c.- d.c. transfer instruments, and A-T (attenuator-thermoelement) voltmeters. Users who have these instruments available will be familiar with their application.

A method of accuracy compatible with that of the 92BD uses a point-by-point frequency scan in conjunction with a power splitter and calibrated power meter. The method is detailed in the following paragraphs.

a. Test Equipment

i. Signal source for the frequency range of 10 to 1200 MHz. Suggested instruments are Wavetek 2001 or H-P 8660 A/C. In this application, the generator is manually swept.

ii. Power Splitter: Weinschel Model 1870A, or H-P 11667A.

iii. Calibrated R.F. Power Meter: Boonton 42B, or H-P 435A.

b. Test Procedure

i. Connect the equipment as shown in Figure 4-2.

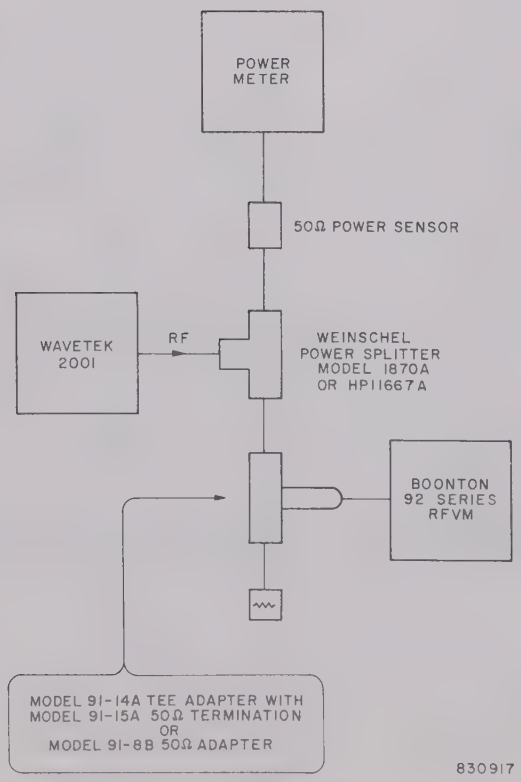

POWER METER
50Ω POWER SENSOR
WAVETEK 2001
RF
WEINSCHEL POWER SPLITTER MODEL 1870A OR HP11667A
BOONTON 92 SERIES RFVM
MODEL 91-14A TEE ADAPTER WITH MODEL 91-15A 50Ω TERMINATION OR MODEL 91-8B 50Ω ADAPTER
830917

**Figure 4-2. Frequency-Response Test Setup**

ii. Set the frequency of the generator to 10 MHz, and adjust the output control for the desired test level. If the response is to be measured at one level only, a test voltage of 100 or 200 mV is recommended.

iii. Disable the output of the generator momentarily and zero the power meter. Re-establish the output level and note the reading on the power meter. Record the frequency of the generator and the reading of the 92BD. Change the frequency, in whatever increments are desired, through the range of 10 to 1200 MHz, holding the reference reading on the power meter constant.

iv. Reverse the output ports of the power splitter and repeat Step iii.

v. The correct voltmeter reading is obtained at each frequency by averaging the two readings. This virtually eliminates the influence of frequency differences of the two ports of the power divider.

vi. Further refinements can be made by filtering the output of the generator, and measuring the complex reflection coefficients of the power meter, r.f. millivoltmeter accessory under test, and all ports of the power divider. The ususal corrections can then be made. These procedures are not usually necessary, and should be done only if the additional accuracy is warranted.

3. Swept-Frequency Response and S.W.R. Another method of measuring both the frequency response and the s.w.r. (in terms of the reflection coefficient), but with somewhat reduced accuracy, employs a sweep generator, external levelling of the generator, an s.w.r. bridge, a power splitter, and a sensitive oscilloscope.

a. Test Equipment

i. Sweep Generator: Wavetek 2001 or H-P 8660 A/C; frequency range 0.01 to 2600 MHz.

ii. S.W.R. Autotester: Wiltron Model 63NF50.

iii. Oscilloscope: Tektronix Model 5110, with two Model 5A20 Vertical Amplifiers.

iv. Power Splitter: Weinschel Model 1870A, or H-P 11667A.

v. Standard 1.2:1 Mismatch Termination: Weinshel M1410-1.2

b. Test Procedure

i. Connect the equipment as in Figure 4-3, and temporarily connect the probe under test to the 92BD. Adjust the output control of the sweep generator for a reading on the 92BD of 100 mV at a fixed frequency of 100 MHz.

ii. Calibrate one of the scope's vertical-input amplifiers for a sensitivity of 100 µV/div. The other vertical amplifier should be calibrated so that a change from 100 mV to 90 mV applied to the input of the probe under test will produce a vertical deflection of two divisions. This can be done easily if a Boonton Electronics 26A R.F. Millivoltmeter Calibrator is available. The probe should be temporarily connected to the output of the calibrator while output levels of 100 mV and 90 mV are alternately selected, and

the sensitivity of the second input amplifier is adjusted for a deflection of two divisions.

iii. Substitute the Standard 1.2:1 Mismatch Termination for the accessory under test, and calibrate the graticule of the oscilloscope for an s.w.r. of 1.2. Replace the accessory and probe.

iv. Adjust the limits on the three bands of the sweep generator for coverage from 10 to 1200 MHz. Study the traces for both frequency response and s.w.r. (return loss).

v. Reverse the output ports of the power splitter and repeat Steps (iii) and (iv).

vi. Note that the permissible error for the frequency-response trace expands with frequency. For meaningful results, the graticule should be marked with a grease pencil, showing maximum permissible errors for the various frequency bands as determined with a calibrated signal of, say, 1 MHz, and at levels above and below the selected test level. Note also that the recovered d.c. from the r.f. probe, which is applied to the second vertical amplifier, will vary as the square of the r.f. input level for test levels of 30 mV or less. Above 30 mV, the r.f.-to-d.c. conversion gradually changes from square law to linear, and approaches a peak-to-peak rectifier at an input of 3 volts.

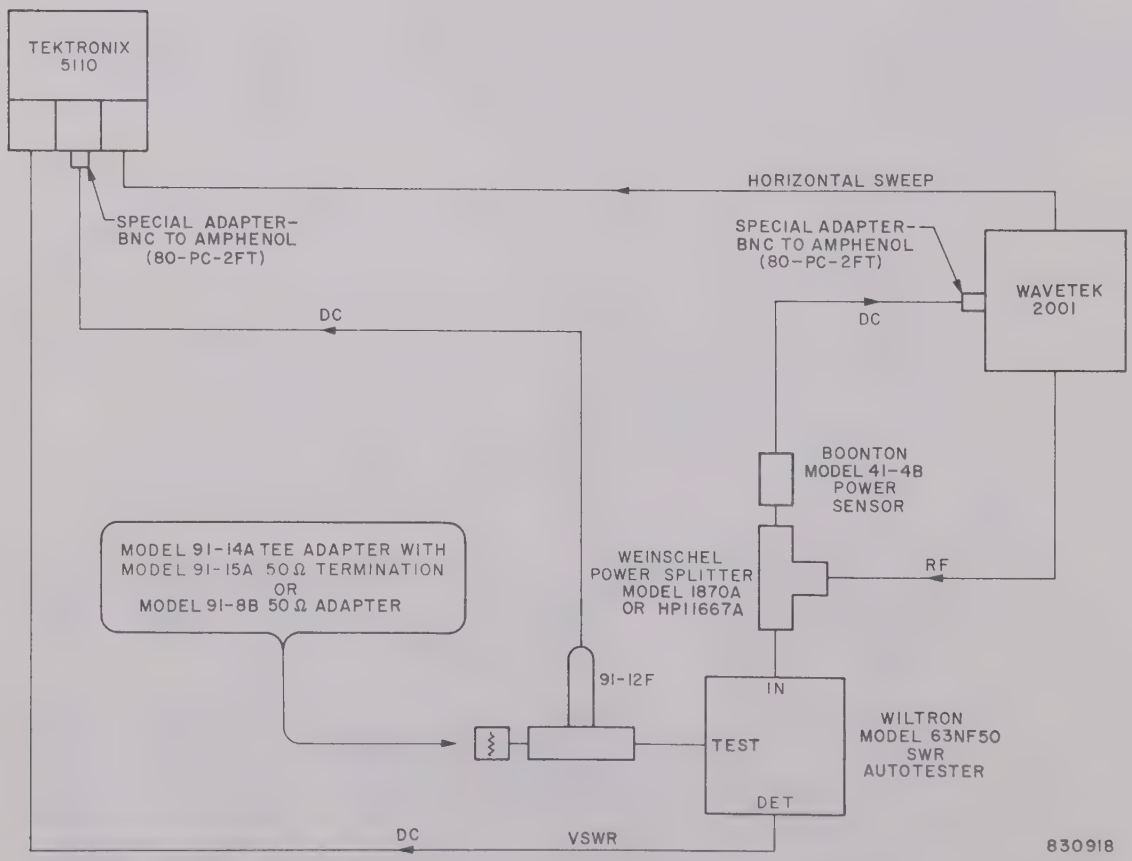



Figure 4-3. Swept-Frequency-Response Test Setup

# S E C T I O N V

## REPLACEABLE PARTS

### 5-1. INTRODUCTION

Table 5-2, Replaceable Parts, identifies the manufacturers of components by five-digit groups taken from the Federal Supply Code for Manufacturers. A list of the applicable code groups and manufacturers is given in Table 5-1.

The Table of Replaceable Parts begins with major assemblies, including PC boards complete with all their parts, followed by miscellaneous parts and components not mounted on PC boards. Then all the components of the individual assemblies (including PC boards) are listed. Note the following:

A. When ordering a component or an assembly, the BEC Part Number is all that we need. However, part numbers can suffer changes during transmission and it is safer to include also a brief description. Example:
BEC Part #200050: Mica Capacitor, 470 pF, 1%, 500V.

B. The number printed on a PC board is not an assembly number; it is the number for the bare board, alone. To order a complete assembly--the board with all its components installed--specify it by the BEC Part Number given in the Assemblies Section of this table.

C. Unless otherwise identified, the number on a schematic diagram or on a parts-location diagram is not an assembly number; it is the number for just the diagram itself.

**Table 5-1. Applicable Federal Supply Code Numbers for Manufacturers**

| | | | |
|---|---|---|---|
| 01121 | Allen Bradley | 32897 | Erie |
| 01139 | General Electric | 32997 | Bourns, Inc., Trimpot Div. |
| 01295 | Texas Instruments | 33883 | RMC |
| 02660 | Amphenol | 34430 | Monsanto |
| 02735 | RCA Solid State Div. | 50088 | Mostek |
| 04222 | AVX Ceramics Company | 54426 | Buss Fuses |
| 04713 | Motorola Semiconductor | 56289 | Sprague Electric Company |
| 06776 | Robinson Nugent, Inc. | 57582 | Kahgan Electronics Corp. |
| 07263 | Fairchild Semiconductor | 59474 | Jeffers Electronics, Inc. |
| 12406 | Elpac Components | 71450 | CTS Corp. |
| 14655 | Cornell-Dubilier | 73138 | Beckman Instr., Helipot Div. |
| 16546 | Centralab | 81840 | Ledex, Inc. |
| 19701 | Mepco Electra | 82389 | Switchcraft |
| 20307 | Arco - Micronics | 84411 | TRW Capacitors |
| 27014 | National Semiconductor | 91293 | Johanson |
| 27735 | F-Dyne Electronics | 91506 | Augat |
| 31313 | Components Corp. | 91637 | Dale Electronics |
| 32293 | Intersil, Inc. | 98291 | Sealectro Corp. |
| 32575 | AMP | S4217 | United Chemicon, Inc. |

**Table 5-2. Replaceable Parts**

| ASSEMBLIES | |
|---|---|
| Input Amplifier | Part Number 092184-01 |
| Input Resistor Networks | Part Numbers 092185-01 & 092186-01 |
| Master Board | Part Number 092142-01 |
| Shaping Amplifier | Part Number 092007-02 |
| Digital Control Board | Part Number 092136-01 |
| Counter Board | Part Number 093006-01 |
| Display Board | Part Number 093008-01 |
| A-D Converter Board | Part Number 093007-01 |
| Switch Assembly | Part Number 042123-02 |
| Meter Assembly | Part Number 042125-06 |
| Chopper Assembly | Part Number 042161-01 |
| Rear-Panel Assembly | Part Number 092033-02 |
| Sub-Panel Assembly | Part Number 092034-03 |

Table 5-2. Replaceable Parts (Continued)

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| INPUT AMPLIFIER, PART NUMBER 092184 | | | | |
| C1 | Capacitor EL 100 µF 20% 25V | S4217 | SM-25-VB-100-M | 283334 |
| C2 | Capacitor EL 100 µF 20% 25V | S4217 | SM-25-VB-100-M | 283334 |
| C3 | Capacitor Mylar 0.1 µF 10% 100V (only) | 19701 | C280MAH/A100K (only) | 234080 |
| C4 | Capacitor Mica 1500 pF 1% 500V | 14655 | CD19FD152F-03 | 200531 |
| C5 | Capacitor Mylar 0.1 µF 10% 100V (only) | 19701 | C280MAH/A100K (only) | 234080 |
| C6 | Capacitor PE 0.022 µF 10% 80V | 56289 | 192P2239R8 | 234096 |
| C7 | Capacitor PE 0.0022 µF 10% 200V | 56289 | 192P22292 | 234110 |
| C8 | Capacitor EL 100 µF 20% 25V | S4217 | SM-25-VB-100-M | 283334 |
| C9 | Capacitor EL 100 µF 20% 25V | S4217 | SM-25-VB-100-M | 283334 |
| C10 | Capacitor PP 0.1 µF 10% 100V | 27735 | PP11-.1-100-10 | 234148 |
| C11 | Capacitor PC 470 nF 10% 50V | 12406 | B5A474K | 234128 |
| C12 | Capacitor EL 10 µF 20% 25V | S4217 | SM-25-VB-10-M | 283336 |
| C13 | Capacitor EL 10 µF 20% 25V | S4217 | SM-25-VB-10-M | 283336 |
| J1-1 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| J1-2 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| J1-3 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| J1-4 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| J1-5 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| J1-6 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| J1-7 | Socket Pin Spring | 02260 | 1-332070-7 | 479333 |
| Q1 | IC CA3096CE Transistor Array | 02735 | CA3096CE | 535101 |
| Q2 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| R1 | Resistor Network 10k ohm 2% SIP | 71450 | 750-101-R10K | 345038 |
| R2 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R3 | Resistor MF 20.0k ohm 1% | 19701 | 5043 (RN55D) | 341429 |
| R4 | Resistor MF 20.0k ohm 1% | 19701 | 5043 (RN55D) | 341429 |
| R5 | Resistor MF 20.0k ohm 1% | 19701 | 5043 (RN55D) | 341429 |
| R6 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R7 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R8 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R9 | Resistor Comp 12M ohm 5% | 01121 | CB | 343708 |
| R10 | Resistor Comp 12M ohm 5% | 01121 | CB | 343708 |
| R11 | Resistor MF 100k ohm 1% | 19701 | 5043 (RN55D) | 341500 |
| R12 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R13 | Resistor MF 1.00k ohm 1% | 19701 | 5043 (RN55D) | 341300 |
| R14 | Resistor MF 221 ohm 1% | 19701 | 5043 (RN55D) | 341233 |
| R15 | Resistor MF 1.00k ohm 1% | 19701 | 5043 (RN55D) | 341300 |
| R16 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R17 | Resistor MF 100k ohm 1% | 19701 | 5043 (RN55D) | 341500 |
| R18 | Resistor MF 8.25k ohm 1% | 19701 | 5043 (RN55D) | 341388 |
| R20 | Resistor MF 8.25k ohm 1% | 19701 | 5043 (RN55D) | 341388 |
| R22 | Resistor MF 15.0k ohm 1% | 19701 | 5043 (RN55D) | 341417 |
| R23 | Resistor MF 1.00M ohm 1% | 19701 | 5043 (RN55D) | 341600 |
| R24 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R25 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R26 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R27 | Resistor MF 806k ohm 1% | 19701 | 5043 (RN55D) | 341587 |
| R28 | Resistor Var 10k ohm 10% 0.5W | 73138 | 72XWR10K | 311348 |
| R29 | Resistor Var 25k ohm 10% 0.5W | 73138 | 72XWR25K | 311385 |
| R36 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R37 | Resistor MF 301k ohm 1% | 19701 | 5043 (RN55D) | 341546 |
| R38 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R39 | Resistor MF 1.00k ohm 1% | 19701 | 5043 (RN55D) | 341300 |
| R40 | Resistor Var 10k ohm 10% 0.5W | 73138 | 72XWR10K | 311348 |
| TP1 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| TP2 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| TP7 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| TP12 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| TP13 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| INPUT AMPLIFIER, PART NUMBER 092184-01 | | | | |
| TP14 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| TP15 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| TP16 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |

## Table 5-2. Replaceable Parts (Continued)

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| **INPUT AMPLIFIER, PART NUMBER 092184-01** | | | | |
| TP17 | Terminal (Test Point) | 31313 | TP-101-10 | 483258 |
| U1 | IC CD4532BE | 02735 | CD4532BE | 534340 |
| U2 | IC IH6208CPE | 32293 | IH6208CPE | 534266 |
| U3 | IC LF356 Op Amp IT/F 535052 | 04901 | BEC | 535062 |
| U4 | IC LF356 Op Amp IT/F 535052 | 04901 | BEC | 535062 |
| U5 | IC CD4011AE | 02735 | CD4011AE | 534022 |
| U6 | IC IT/F535052 Op Amp | 04901 | BEC | 535079 |
| U7 | IC CD4001AE | 02735 | CD4001AE | 534023 |
| U8 | IC CA3140AE Op Amp | 02735 | CA3140AE | 535050 |
| U9 | IC IH6108CPE | 32293 | IH6108CPE | 534265 |
| U10 | IC CD4047AE (RCA only) | 02735 | CD4047AE | 534229 |
| U11 | IC CD4016BE | 02735 | RCA only | 534218 |
| U12 | IC CD4030AE | 02735 | CD4030AE | 534087 |
| U13 | IC CD4013BE (only) | 02735 | CD4013BE | 534205 |
| U14 | IC 78L05AWC Regulator | 07263 | 78L05AWC | 535044 |
| U15 | IC 79L05ACP Regulator | 04713 | MC79L05ACP | 535090 |
| U16 | IC CD4081BE | 02735 | CD4081BE | 534142 |
| U17 | IC CA3140AE Op Amp | 02735 | CA3140AE | 535050 |
| XQ1 | Socket IC 16 Pin | 06776 | ICN-163-S3-G | 473042 |
| XU1 | Socket IC 16 Pin | 06776 | ICN-163-S3-G | 473042 |
| XU2 | Socket IC 16 Pin | 06776 | ICN-163-S3-G | 473042 |
| XU3 | Socket IC 8 Pin | 06776 | ICN-083-S3-G | 473041 |
| XU4 | Socket IC 8 Pin | 06776 | ICN-083-S3-G | 473041 |
| XU5 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU6 | Socket IC 8 Pin | 06776 | ICN-083-S3-G | 473041 |
| XU7 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU8 | Socket IC 8 Pin | 06776 | ICN-083-S3-G | 473041 |
| XU9 | Socket IC 16 Pin | 06776 | ICN-163-S3-G | 473042 |
| XU10 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU11 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU12 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU13 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU16 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU17 | Socket IC 8 Pin | 06776 | ICN-083-S3-G | 473041 |
| **INPUT RESISTOR NETWORK, PART NUMBER 092185-01** | | | | |
| R19 | Resistor MF 1.00k ohm 1% | 19701 | 5063J | 338300 |
| R21 | Resistor MF 1.00k ohm 1% | 19701 | 5063J | 338300 |
| **INPUT RESISTOR NETWORK, PART NUMBER 092186-01** | | | | |
| R30 | Resistor MF 37.4k ohm 1% | 19701 | 5063J | 338455 |
| R31 | Resistor MF 41.2k ohm 1% | 19701 | 5063J | 338459 |
| R32 | Resistor MF 15.8k ohm 1% | 19701 | 5063J | 338419 |
| R33 | Resistor MF 4.02k ohm 1% | 19701 | 5063J | 338358 |
| R34 | Resistor MF 1.15k ohm 1% | 19701 | 5063J | 338306 |
| R35 | Resistor MF 274 ohm 1% | 19701 | 5063J | 338242 |
| **MASTER BOARD, PART NUMBER 092142-01** | | | | |
| C112 | Capacitor EL 1000 µF -10/+50% 35V | 57582 | KSMM-1000-35 | 283350 |
| C113 | Capacitor EL 1000 µF -10/+50% 35V | 57582 | KSMM-1000-35 | 283350 |
| C114 | Capacitor EL 4700 µF -10%/+50% 16V | 57582 | KSMM-4700-16 | 283352 |
| C115 | Capacitor Cer 0.001 µF 500V | 33883 | Z5U | 224114 |
| C116 | Capacitor Cer 0.001 µF 500V | 33883 | Z5U | 224114 |
| C117 | Capacitor Tant 10 µF 20% 20V | 56289 | 196D106X0020FB | 283205 |
| C118 | Capacitor EL 100 µF 25V | 56289 | TE-1211 (30D107G025DD2) | 283105 |
| C119 | Capacitor EL 100 µF 25V | 56289 | TE-1211 (30D107G025DD2) | 283105 |
| C120 | Capacitor Cer 1.0 µF 20% 50V | 04222 | SR305E105MAA | 224264 |
| C121 | Capacitor Cer 1.0 µF 20% 50V | 04222 | SR305E105MAA | 224264 |
| CR107 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR108 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR109 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR110 | Diode 1N914 | 01295 | 1N914 | 530058 |

Table 5-2. Replaceable Parts (Continued)

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| SHAPING AMPLIFIER, PART NUMBER 092007-02 | | | | |
| Q326 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| Q327 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q328 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| Q329 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q330 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| Q331 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| Q332 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q333 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q334 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q335 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| Q336 | Transistor FET 2N5949 N-Channel | 04713 | 2N5949 | 528019 |
| Q337 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q338 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q339 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| R301 | Resistor Comp 130 ohm 5% | 01121 | EB | 344211 |
| R302 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R303 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R304 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R305 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R306 | Resistor MF 51.1k ohm 1% | 19701 | 5043 (RN55D) | 341468 |
| R307 | Resistor MF 2.49k ohm 1% | 19701 | 5043 (RN55D) | 341338 |
| R308 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R309 | Resistor MF 28.7k ohm 1% | 19701 | 5043 (RN55D) | 341444 |
| R310 | Resistor MF 210k ohm 1% | 19701 | 5043 (RN55D) | 341531 |
| R311 | Resistor MF 100k ohm 1% | 19701 | 5043 (RN55D) | 341500 |
| R312 | Resistor MF 42.2k ohm 1% | 19701 | 5043 (RN55D) | 341460 |
| R313 | Resistor MF 191k ohm 1% | 19701 | 5043 (RN55D) | 341527 |
| R314 | Resistor MF 11.0k ohm 1% | 19701 | 5043 (RN55D) | 341404 |
| R315 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R316 | Resistor MF 29.4k ohm 1% | 19701 | 5043 (RN55D) | 341445 |
| R317 | Resistor MF 95.3k ohm 1% | 19701 | 5043 (RN55D) | 341494 |
| R318 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R319 | Resistor MF 27.4k ohm 1% | 19701 | 5043 (RN55D) | 341442 |
| R320 | Resistor MF 64.9K ohm 1% | 19701 | 5043 (RN55D) | 341478 |
| R321 | Resistor MF 1.0M ohm 1% | 19701 | 5043 (RN60D) | 342600 |
| R322 | Resistor MF 26.1k ohm 1% | 19701 | 5043 (RN55D) | 341440 |
| R323 | Resistor MF 46.4k ohm 1% | 19701 | 5043 (RN55D) | 341464 |
| R324 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R325 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R326 | Resistor MF 45.3k ohm 1% | 19701 | 5043 (RN55D) | 341463 |
| R327 | Resistor MF 2.49k ohm 1% | 19701 | 5043 (RN55D) | 341338 |
| R328 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R329 | Resistor Comp 390k ohm 5% | 01121 | EB | 344557 |
| R330 | Resistor MF 21.5k ohm 1% | 19701 | 5043 (RN55D) | 341432 |
| R331 | Resistor MF 237k ohm 1% | 19701 | 5043 (RN55D) | 341536 |
| R332 | Resistor Comp 22k ohm 5% | 01121 | EB | 344433 |
| R333 | Resistor MF 26.1k ohm 1% | 19701 | 5043 (RN55D) | 341440 |
| R334 | Resistor MF 150k ohm 1% | 19701 | 5043 (RN55D) | 341517 |
| R335 | Resistor Comp 47k ohm 5% | 01121 | EB | 344465 |
| R336 | Resistor MF 54.9k ohm 1% | 19701 | 5043 (RN55D) | 341471 |
| R337 | Resistor MF 178k ohm 1% | 19701 | 5043 (RN55D) | 341524 |
| R338 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R339 | Resistor MF 82.5k ohm 1% | 19701 | 5043 (RN55D) | 341488 |
| R340 | Resistor MF 178k ohm 1% | 19701 | 5043 (RN55D) | 341524 |
| R341 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R342 | Resistor MF 17.8k ohm 1% | 19701 | 5043 (RN55D) | 341424 |
| R343 | Resistor MF 2.74k ohm 1% | 19701 | 5043 (RN55D) | 341342 |
| R344 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R345 | Resistor MF 24.3k ohm 1% | 19701 | 5043 (RN55D) | 341437 |
| R346 | Resistor MF 232k ohm 1% | 19701 | 5043 (RN55D) | 341535 |
| R347 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R348 | Resistor MF 95.3k ohm 1% | 19701 | 5043 (RN55D) | 341494 |
| R349 | Resistor MF 453k ohm 1% | 19701 | 5043 (RN55D) | 341563 |
| R350 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R351 | Resistor MF 200k ohm 1% | 19701 | 5043 (RN55D) | 341529 |
| R352 | Resistor MF 634k ohm 1% | 19701 | 5043 (RN60D) | 342577 |

Table 5-2. Replaceable Parts (Continued)

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| SHAPING AMPLIFIER, PART NUMBER 092007-02 | | | | |
| R353 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R354 | Resistor MF 14.3k ohm 1% | 19701 | 5043 (RN55D) | 341415 |
| R355 | Resistor MF 2.49k ohm 1% | 19701 | 5043 (RN55D) | 341338 |
| R356 | Resistor MF 34.8K ohm 1% | 19701 | 5043 (RN55D) | 341452 |
| R357 | Resistor MF 523k ohm 1% | 19701 | 5043 (RN60D) | 342569 |
| R358 | Resistor Comp 4.7M ohm 5% | 01121 | EB | 344665 |
| R359 | Resistor MF 162k ohm 1% | 19701 | 5043 (RN55D) | 341520 |
| R360 | Resistor MF 806k ohm 1% | 19701 | 5043 (RN60D) | 342587 |
| R361 | Resistor MF 10.0k ohm 1% | 19701 | 5043 (RN55D) | 341400 |
| R362 | Resistor MF 2.74k ohm 1% | 19701 | 5043 (RN55D) | 341342 |
| R363 | Resistor Var 1k ohm ±10% 1W | 91637 | Model 784 | 311256 |
| R364 | Resistor MF 127k ohm 1% | 19701 | 5043 (RM55D) | 341510 |
| R365 | Resistor MF 604k ohm 1% | 19701 | 5043 (RN60D) | 342575 |
| RT301 | Thermistor 100 ohm ±10% | 00241 | CB21J1 | 325005 |
| DIGITAL CONTROL BOARD, PART NUMBER 092136-01 | | | | |
| A604 | IC LM301AN Op Amp | 27014 | LM301AN | 535012 |
| A605 | IC LM301AN Op Amp | 27014 | LM301AN | 535012 |
| C606 | Capacitor Cer 0.01 µF 100V | 32897 | 805-000X5V0103Z | 224119 |
| C607 | Capacitor Cer 0.01 µF 100V | 32897 | 805-000X5V0103Z | 224119 |
| CR602 | Diode 1N5236B | 04713 | Zener 1N5236B 7.5V | 530087 |
| CR604 | Diode 1N5227B | 04713 | Zener 1N5227B 3.6V | 530095 |
| CR605 | Diode 1N5227B | 04713 | Zener 1N5227B 3.6V | 530095 |
| IC601 | IC SN74L10N | 01295 | SN74L10N | 534029 |
| IC602 | IC SN74L00N | 01295 | SN74L00N | 534002 |
| IC603 | IC CD4002AF | 02735 | CD4002AF | 534044 |
| IC604 | IC CD4002AF | 02735 | CD4002AF | 534044 |
| IC605 | IC SN74L00N | 01295 | SN74L00N | 534002 |
| IC606 | IC CD4016AE Quad Switch | 02735 | CD4016AE | 534007 |
| IC607 | IC SN74L00N | 01295 | SN74L00N | 534002 |
| Q602 | Transistor FET 2N5653 | 04713 | 2N5653 | 528056 |
| Q603 | Transistor FET 2N5653 | 04713 | 2N5653 | 528056 |
| Q605 | Transistor FET 2N5653 | 04713 | 2N5653 | 528056 |
| Q607 | Transistor PNP 2N3905 | 04713 | 2N3905 | 528025 |
| Q608 | Transistor PNP 2N3905 | 04713 | 2N3905 | 528025 |
| Q609 | Transistor FET 2N5653 | 04713 | 2N5653 | 528056 |
| Q610 | Transistor PNP 2N3905 | 04713 | 2N3905 | 528025 |
| R603 | Resistor Comp 4.7k ohm 5% | 01121 | EB | 344365 |
| R604 | Resistor Comp 4.7k ohm 5% | 01121 | EB | 344365 |
| R606 | Resistor Comp 4.7k ohm 5% | 01121 | EB | 344365 |
| R608 | Resistor Comp 4.7k ohm 5% | 01121 | EB | 344365 |
| R609 | Resistor Comp 100k ohm 5% | 01121 | EB | 344500 |
| R610 | Resistor Comp 100k ohm 5% | 01121 | EB | 344500 |
| R611 | Resistor Comp 100k ohm 5% | 01121 | EB | 344500 |
| R612 | Resistor Comp 100k ohm 5% | 01121 | EB | 344500 |
| R613 | Resistor Comp 15k ohm 5% | 01121 | EB | 344417 |
| R618 | Resistor Comp 100k ohm 5% | 01121 | EB | 344500 |
| R623 | Resistor Comp 100k ohm 5% | 01121 | EB | 344500 |
| R624 | Resistor Comp 10k ohm 5% | 01121 | EB | 344400 |
| R625 | Resistor Comp 4.7k ohm 5% | 01121 | EB | 344365 |
| R632 | Resistor Var 200 ohm ±10% 1W | 91637 | Model 784 | 311269 |
| R633 | Resistor MF 2.05k ohm 1% | 19701 | 5043 (RN55D) | 341330 |
| R635 | Resistor MF 953 ohm 1% | 19701 | 5043 (RN55D) | 341294 |
| R636 | Resistor MF 16.9k ohm 1% | 19701 | 5043 (RN55D) | 341422 |
| R637 | Resistor MF 13.0k ohm 1% | 19701 | 5043 (RN55D) | 341411 |
| R638 | Resistor MF 11.5k ohm 1% | 19701 | 5043 (RN55D) | 341406 |
| R639 | Resistor MF 33.2k ohm 1% | 19701 | 5043 (RN55D) | 341450 |
| R640 | Resistor MF 80.6k ohm 1% | 19701 | 5043 (RN55D) | 341487 |
| R641 | Resistor Comp 10k ohm 5% | 01121 | EB | 344400 |
| R642 | Resistor Comp 10k ohm 5% | 01121 | EB | 344400 |
| R643 | Resistor MF 9.76k ohm 1% | 19701 | 5043 (RN55D) | 341395 |
| R644 | Resistor Var 2k ohm ±10% 1W | 91637 | 784 | 311264 |
| R645 | Resistor Var 100 ohm 10% 1W | | | 311383 |

Table 5-2. Replaceable Parts (Continued)

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| COUNTER BOARD, PART NUMBER 093006-01 | | | | |
| CR1201 | Diode 1N5234B | 04713 | Zener 1N5234B 6.2V | 530093 |
| CR1202 | Diode 1N5234B | 04713 | Zener 1N5234B 6.2V | 530093 |
| CR1203 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR1204 | Diode 1N914 | 01295 | 1N914 | 530058 |
| C1201 | Capacitor Tant 200 µF -10/+75 6V | 56289 | TE-1104 | 283147 |
| C1203 | Capacitor Cer Var 4.5-50 pF 250V | 91293 | #9305 (Green) | 281009 |
| C1204 | Capacitor Mica 33 pF 5% 500V | 20307 | DM-15-330J | 200049 |
| C1205 | Capacitor Mylar .01 µF 20% 250V | 19701 | C280AE/P10K | 234085 |
| C1206 | Capacitor Mylar 0.1 µF 10% 100V (only) | 19701 | C280MAH/A100K (only) | 234080 |
| C1207 | Capacitor Cer 33 pF 10% 100V | 04222 | MC71A330K | 224218 |
| C1208 | Capacitor Tant 47 µF 10% 20V (only) | 56289 | 196D476X9020PE4 | 283219 |
| C1209 | Capacitor Tant 10 µF 20% 20V | 56289 | 196D106X0020FB | 283205 |
| IC1201 | IC SN74L00N | 01295 | SN74L00N | 534002 |
| IC1202 | IC MK5002P | 50088 | MK5002P | 534024 |
| J1202 | Connector Receptacle (female) | 32575 | 583485-8 | 479277 |
| J1203 | Connector Receptacle (female) | 32575 | 583485-8 | 479277 |
| J1204 | Connector Receptacle (female) | 32575 | 583485-8 | 479277 |
| Q1201 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1202 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1203 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1204 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1205 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1206 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1207 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1208 | Transistor MPS 6516 | 04713 | MPS6516 | 528037 |
| Q1209 | Transistor NPN MPS6507 | 04713 | MPS6507 | 528070 |
| Q1210 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1211 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1212 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1213 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1214 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1215 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1216 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1217 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1218 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1219 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1220 | Transistor UJT MPU-131 | 04713 | MPU-131 | 528062 |
| Q1221 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1222 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1223 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| Q1224 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| R1201 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1202 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1203 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1204 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1205 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1206 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1207 | Resistor Comp 2.0k ohm 5% | 01121 | CB | 343329 |
| R1208 | Resistor Comp 1.0k ohm 5% | 01121 | CB | 343300 |
| R1209 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1210 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1211 | Resistor Comp 75k ohm 5% | 01121 | CB | 343484 |
| R1212 | Resistor Comp 100k ohm 5% | 01121 | CB | 343500 |
| R1213 | Resistor Comp 100k ohm 5% | 01121 | CB | 343500 |
| R1214 | Resistor Comp 100k ohm 5% | 01121 | CB | 343500 |
| R1215 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1216 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1217 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1218 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1219 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1220 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1221 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1222 | Resistor Comp 3.0k ohm 5% | 01121 | CB | 343346 |
| R1223 | Resistor Comp 680 ohm 5% | 01121 | CB | 343280 |
| R1224 | Resistor Comp 430 ohm 5% | 01121 | CB | 343261 |

Table 5-2. Replaceable Parts (Continued)

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| COUNTER BOARD, PART NUMBER 093006-01 | | | | |
| R1225 | Resistor Comp 680k ohm 5% | 01121 | CB | 343580 |
| R1226 | Resistor Comp 100k ohm 5% | 01121 | CB | 343500 |
| R1227 | Resistor Comp 680k ohm 5% | 01121 | CB | 343580 |
| R1228 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1229 | Resistor Comp 330 ohm 5% | 01121 | CB | 343250 |
| R1230 | Resistor Comp 4.7M ohm 5% | 01121 | CB | 343665 |
| R1231 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1232 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1233 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1234 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1235 | Resistor Comp 430 ohm 5% | 01121 | CB | 343261 |
| XU1201 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| Replaceable Parts List for One Of The Following Values To Be Used | | | PL 000093-01 | |
| C1202 | Capacitor Mica 120pF 5% 500V | 20307 | DM15-F121J | 200002 |
| C1202 | Capacitor Mica 56 pF 5% 500V | 20307 | DM15-560J | 200030 |
| C1202 | Capacitor Mica 150 pF 5% 500V | 20307 | DM15-151J | 200032 |
| C1202 | Capacitor Mica 91 pF 5% 500V | 20307 | DM15-910J | 200035 |
| C1202 | Capacitor Mica 33 pF 5% 500V | 20307 | DM15-330J | 200049 |
| DISPLAY BOARD, PART NUMBER 093008-01 | | | | |
| CR1301 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR1302 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR1303 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR1304 | Diode 1N914 | 01295 | 1N914 | 530058 |
| C1301 | Capacitor Tant 10 µF 20% 20V | 56289 | 196D106X0020FB | 283205 |
| DS1301 | Display Numeric MAN-3620 | 34430 | Man 3620 | 536805 |
| DS1302 | Display Numeric MAN-3620 | 34430 | Man 3620 | 536805 |
| DS1303 | Display Numeric MAN-3620 | 34430 | Man 3620 | 536805 |
| DS1304 | Lamp 5V 583DX | 01139 | 583D-120 | 545127 |
| DS1305 | Lamp 5V 2200D | 01139 | T1 1.75 | 545120 |
| DS1306 | Lamp 5V 2200D | 01139 | T1 1.75 | 545120 |
| DS1307 | Lamp 5V 2200D | 01139 | T1 1.75 | 545120 |
| DS1308 | Display Numeric MAN-3620 | 34430 | Man 3620 | 536805 |
| DS1309 | Lamp 5V 2200D | 01139 | T1 1.75 | 545120 |
| DS1310 | Lamp 5V 2200D | 01139 | T1 1.75 | 545120 |
| DS1311 | Lamp 5V 2200D | 01139 | T1 1.75 | 545120 |
| L1301 | Inductor 33 µH 5% | 59474 | 4465-2J | 400310 |
| Q1301 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1302 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1303 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1304 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1305 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1306 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1307 | Transistor NPN 2N5088 | 04713 | 2N5088 | 528047 |
| Q1308 | Transistor NPN MPS-A12 | 04713 | MPS-A12 | 528052 |
| Q1309 | Transistor NPN MPS-A12 | 04713 | MPS-A12 | 528052 |
| Q1310 | Transistor NPN MPS-A12 | 04713 | MPS-A12 | 528052 |
| Q1311 | Transistor NPN MPS-A12 | 04713 | MPS-A12 | 528052 |
| Q1312 | Transistor PNP 2N5087 | 04713 | 2N5087 | 528042 |
| R1301 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1302 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1303 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1304 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1305 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1306 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1307 | Resistor Comp 47 ohm 5% | 01121 | CB | 343165 |
| R1308 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1309 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1310 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1311 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1312 | Resistor Comp 33 ohm 5% | 01121 | CB | 343150 |

**Table 5-2. Replaceable Parts (Continued)**

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| A-D CONVERTER BOARD, PART NUMBER 093007-01 | | | | |
| A1401 | IC LM310H Op Amp (only) | 27014 | LM310H | 535005 |
| A1402 | IC LM301AN Op Amp | 27014 | LM301AN | 535012 |
| A1403 | IC LM310H Op Amp (only) | 27014 | LM310H | 535005 |
| A1404 | IC LM311H Voltage Comparator | 27014 | LM311H | 535006 |
| CR1401 | Diode 1N821 | 08077 | 1N821 | 530050 |
| CR1402 | Diode 1N821 | 08077 | 1N821 | 530050 |
| CR1403 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR1404 | Diode 1N914 | 01295 | 1N914 | 530058 |
| CR1405 | Diode 1N914 | 01295 | 1N914 | 530058 |
| C1401 | Capacitor Tant 1 µF 10% 35V (only) | 56289 | 196D105X9035HA1 (only) | 283216 |
| C1402 | Capacitor Tant 1 µF 10% 35V (only) | 56289 | 196D105X9035HA1 (only) | 283216 |
| C1403 | Capacitor .01µf 10% 50V | 84411 | TRW | 234115 |
| C1404 | Capacitor Cer 33 pF 5% 1 kV | 56289 | C030B102G330J (10TCC-Q33) | 224139 |
| C1405 | Capacitor Tant 1 µF 10% 35V (only) | 56289 | 196D105X9035HA1 (only) | 283216 |
| C1406 | Capacitor .01µf 10% 50V | 84411 | TRW | 234115 |
| C1407 | Capacitor Mica 100 pF 5% 300V | 20307 | DM5-FC101J | 205006 |
| IC1401 | IC CD4016AE Quad Switch | 02735 | CD4016AE | 534007 |
| IC1402 | IC CD4013AE | 02735 | CD4013AE | 534021 |
| IC1403 | IC CD4011AE | 02735 | CD4011AE | 534022 |
| IC1404 | IC CD4001AE | 02735 | CD4001AE | 534023 |
| Q1401 | Transistor JFET 2N5953 | 04901 | BEC | 528145 |
| R1401 | Resistor MF 30.9k ohm 1% | 19701 | 5043 (RN55D) | 341447 |
| R1402 | Resistor MF 30.9k ohm 1% | 19701 | 5043 (RN55D) | 341447 |
| R1403 | Resistor MF 5.49k ohm 1% | 19701 | 5043 (RN55D) | 341371 |
| R1404 | Resistor MF 5.49k ohm 1% | 19701 | 5043 (RN55D) | 341371 |
| R1405 | Resistor Var 5k ohm ±20% 0.5W | 32997 | 3359W-1-502 | 311293 |
| R1406 | Resistor MF 1.15k ohm 1% | 19701 | 5043 (RN55D) | 341306 |
| R1407 | Resistor MF 200k ohm 1% | 19701 | 5043 (RN55D) | 341529 |
| R1408 | Resistor Var 5k ohm ±20% 0.5W | 32997 | 3359W-1-502 | 311293 |
| R1409 | Resistor Comp 330 ohm 5% | 01121 | CB | 343250 |
| R1410 | Resistor Comp 10k ohm 5% | 01121 | CB | 343400 |
| R1411 | Resistor MF 1.15k ohm 1% | 19701 | 5043 (RN55D) | 341306 |
| R1412 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1413 | Resistor Comp 4.7M ohm 5% | 01121 | CB | 343665 |
| R1414 | Resistor Comp 680 ohm 5% | 01121 | CB | 343280 |
| R1415 | Resistor Comp 27k ohm 5% | 01121 | CB | 343441 |
| R1416 | Resistor Comp 5.1k ohm 5% | 01121 | CB | 343368 |
| R1417 | Resistor Comp 10k ohm 5% | 01121 | CB | 343400 |
| R1418 | Resistor Comp 4.7M ohm 5% | 01121 | CB | 343665 |
| R1419 | Resistor Comp 1.0M ohm 5% | 01121 | CB | 343600 |
| R1420 | Resistor Comp 47k ohm 5% | 01121 | CB | 343465 |
| XA1402 | Socket IC 8 Pin | 06776 | ICN-083-S3-G | 473041 |
| XU1401 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU1402 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU1403 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| XU1404 | Socket IC 14 Pin | 06776 | ICN-143-S3-G | 473019 |
| SWITCH ASSEMBLY, PART NUMBER 042123-02 | | | | |
| S401 | Switch Modified M/F 465153 | 16546 | Series PB-10 | 465154 |
| METER ASSEMBLY, PART NUMBER 042125-06 | | | | |
| M401 | Meter & Scale M/F 554253, 554293 | 04901 | BEC | 554294 |
| CHOPPER ASSEMBLY, PART NUMBER 042161-01 | | | | |
| C1 | Capacitor PP 0.1 µF 10% 100V | 27735 | PP11-.1-100-10 | 234148 |
| C2 | Capacitor PP 0.1 µF 10% 100V | 27735 | PP11-.1-100-10 | 234148 |
| IC1 | IC CD4016BE (only) IT/F 534354 PED4200-3 | 04901 | BEC | 534223 |
| P1-1 | Terminal | 98291 | 229-1071-23 | 510038 |
| P1-2 | Terminal | 98291 | 229-1071-23 | 510038 |
| P1-3 | Terminal | 98291 | 229-1071-23 | 510038 |
| P1-4 | Terminal | 98291 | 229-1071-23 | 510038 |
| P1-5 | Terminal | 98291 | 229-1071-23 | 510038 |

**Table 5-2. Replaceable Parts (Continued)**

| Item | Description | Mfr. | Mfr's Part No. | Part No. |
|---|---|---|---|---|
| A-D CONVERTER BOARD, PART NUMBER 093007-01 | | | | |
| P1-6 | Terminal | 98291 | 229-1071-23 | 510038 |
| P1-7 | Terminal | 98291 | 229-1071-23 | 510038 |
| R3 | Resistor MF 51.1k ohm 1% | 19701 | 5043 (RN55D) | 341468 |
| R4 | Resistor Var 20k ohm 10% 0.5W | 73138 | 72PR20K | 311354 |
| R5 | Resistor Var 20k ohm 10% 0.5W | 73138 | 72PR20K | 311354 |
| R6 | Resistor MF 51.1k ohm 1% | 19701 | 5043 (RN55D) | 341468 |
| XIC1 | Socket IC 14 Pin | 91506 | 508-AG7D | 473056 |
| REAR-PANEL ASSEMBLY, PART NUMBER 092033-02 | | | | |
| F401 | Fuse 0.2 A | 54426 | MDL 0.2 | 545508 |
| F401 | Fuse 0.1 A Slo-Blo | 54426 | MDL | 545519 |
| S402 | Switch Slide | 82389 | 46202LR | 465134 |
| T401 | Transformer Power | 04901 | BEC | 446071 |
| SUB-PANEL ASSEMBLY, PART NUMBER 092034-03 | | | | |
| J401 | Connector Assembly (female) | 04901 | BEC | 092141 |
| R401 | Resistor Var 5k ohm M/F 311413 | 04901 | BEC | 311270 |
| S403 | Switch Rotary | 81840 | Series 312 | 466212 |

# SECTION VI

## SCHEMATIC DIAGRAMS

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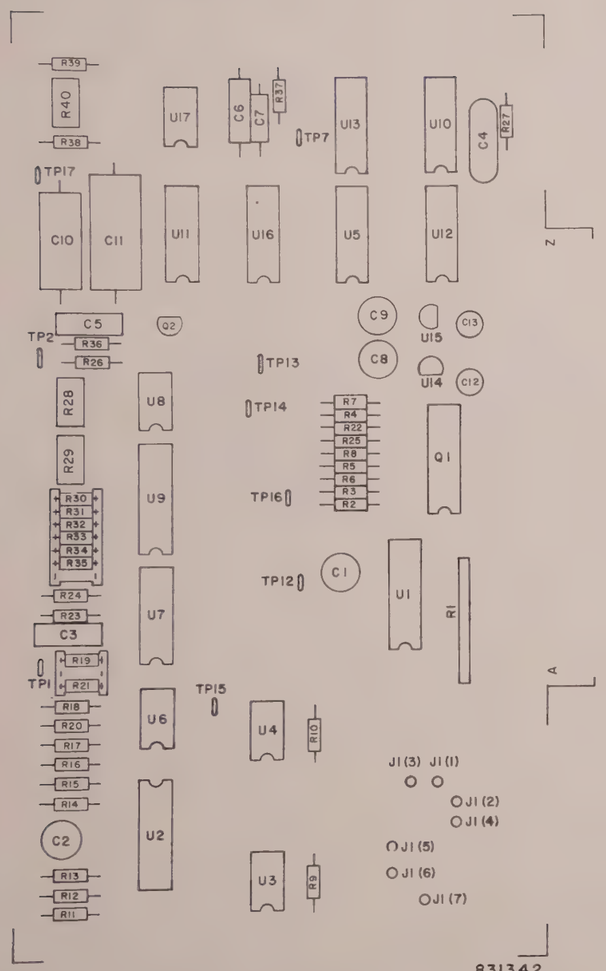
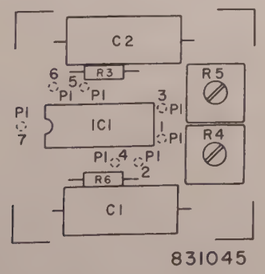
NOTES




Input Amplifier Parts-Location Diagram (C831342A)




Chopper Board Parts-Location Diagram (B831045D)

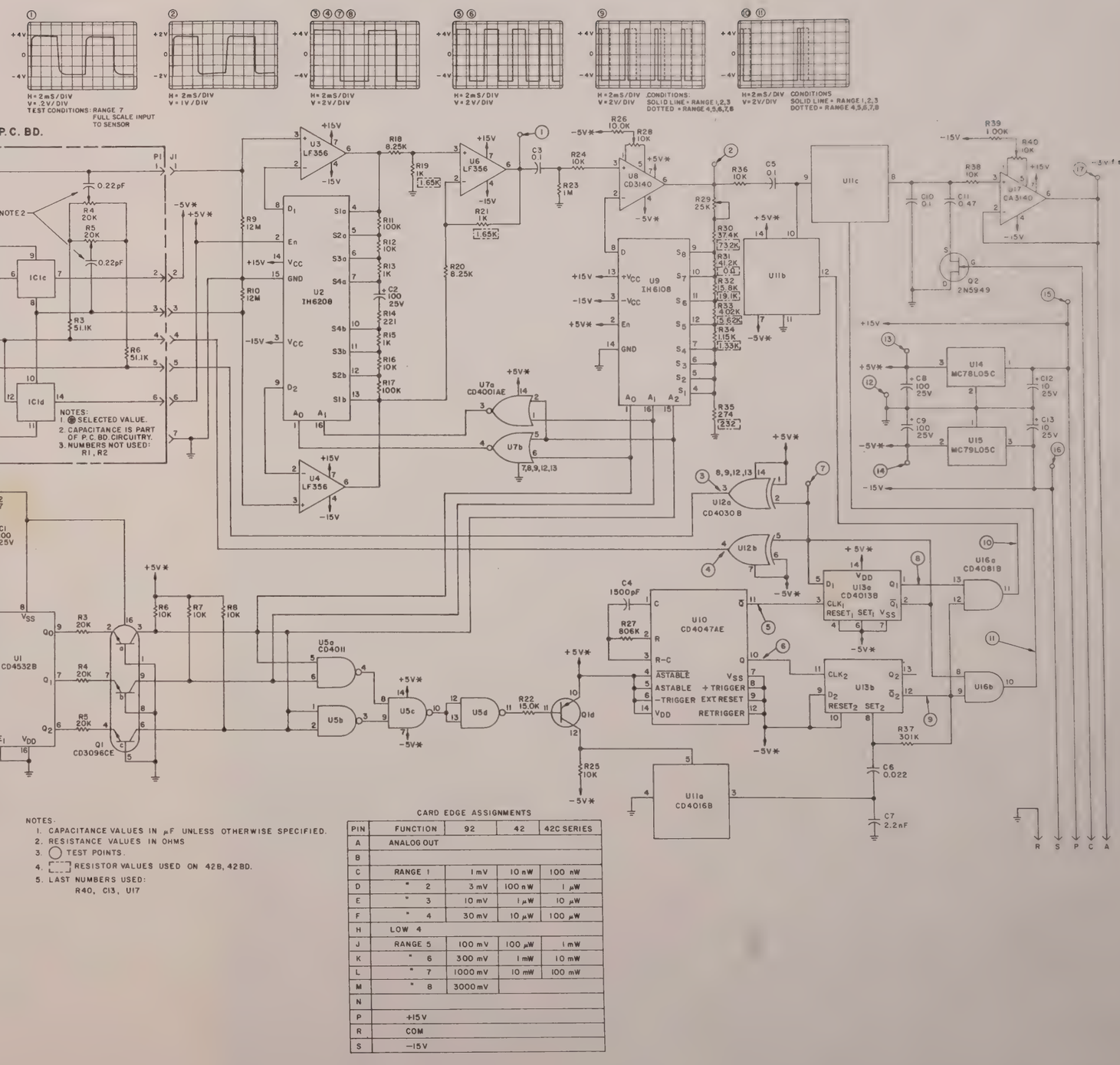
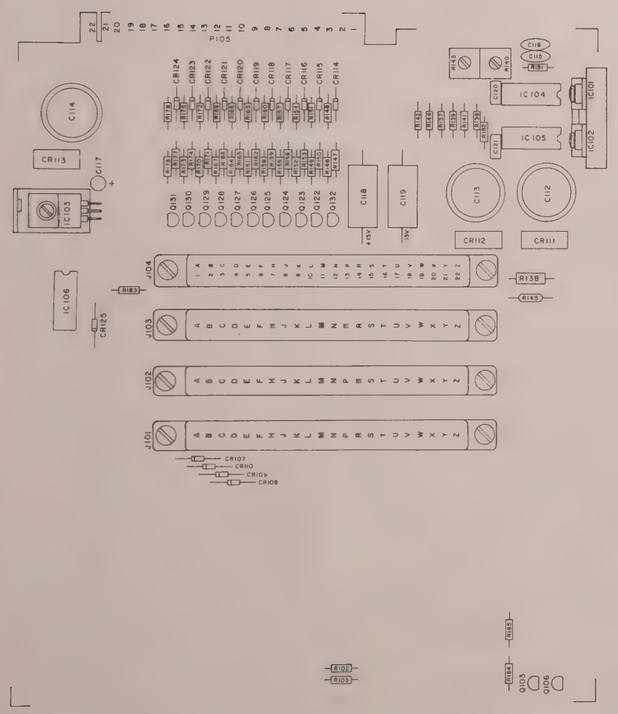

① H=2mS/DIV V=2V/DIV TEST CONDITIONS: RANGE 7 FULL SCALE INPUT TO SENSOR
② H=2mS/DIV V=1V/DIV
③④⑦⑧ H=2mS/DIV V=2V/DIV
⑤⑥ H=2mS/DIV V=2V/DIV
⑨ H=2mS/DIV V=2V/DIV CONDITIONS: SOLID LINE = RANGE 1,2,3 DOTTED = RANGE 4,5,6,7,8
⑩⑪ H=2mS/DIV V=2V/DIV CONDITIONS SOLID LINE = RANGE 1,2,3 DOTTED = RANGE 4,5,6,7,8
A2 INPUT AMPLIFIER P.C. BD.
A4 CHOPPER P.C. BD.
NOTES:
1. ⊛ SELECTED VALUE.
2. CAPACITANCE IS PART OF P.C. BD. CIRCUITRY.
3. NUMBERS NOT USED: R1, R2
NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS
3. ◯ TEST POINTS.
4. [ ] RESISTOR VALUES USED ON 42B, 42BD.
5. LAST NUMBERS USED: R40, C13, U17
CARD EDGE ASSIGNMENTS
PIN | FUNCTION | 92 | 42 | 42C SERIES
A | ANALOG OUT
B
C | RANGE 1 | 1 mV | 10 nW | 100 nW
D | " 2 | 3 mV | 100 nW | 1 μW
E | " 3 | 10 mV | 1 μW | 10 μW
F | " 4 | 30 mV | 10 μW | 100 μW
H | LOW 4
J | RANGE 5 | 100 mV | 100 μW | 1 mW
K | " 6 | 300 mV | 1 mW | 10 mW
L | " 7 | 1000 mV | 10 mW | 100 mW
M | " 8 | 3000 mV
N
P | +15V
R | COM
S | −15V
CARD EDGE C D E F H J K L M
R S P C A

Figure 6-1. Input Amplifier Board Schematic Diagram (E831308B)



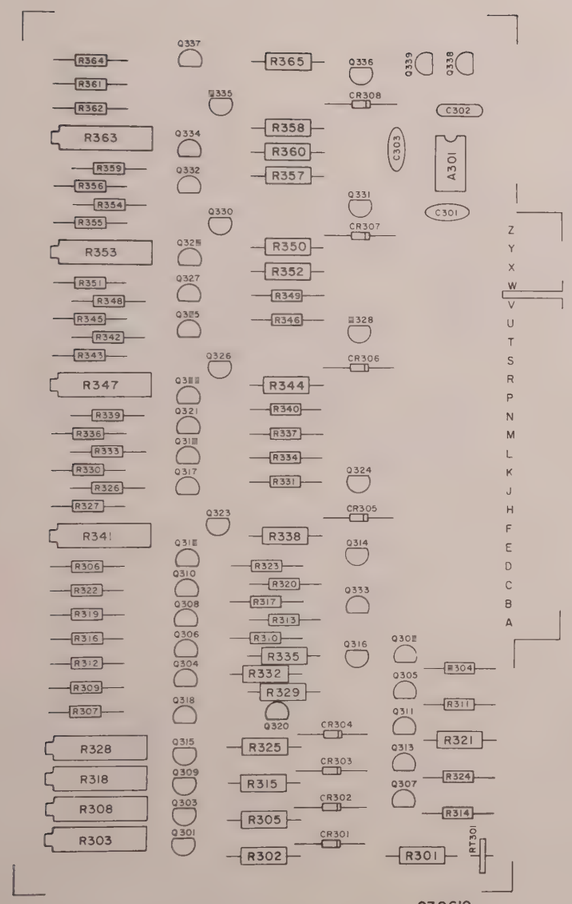

Parts-Location Diagram (D831348A)

DVM AND AMPLIFIER PCB INTERCONNECTION TABLE

| J1201 DVM CONNECTOR | | | | | | | |
|---|---|---|---|---|---|---|---|
| J1201 | PCB | WIRE | FUNCTION | J1201 | PCB | WIRE | FUNCTION |
| 1 | 38 | WHT/BLK/GY | ENCODE | | | | |
| 1 | 54 | WHT/YEL | COMPLETE | A | 51 | WHT/BRN | −dBm |
| 2 | 52 | WHT/BLK | +5V | B | 55 | WHT/GRN | +5V |
| 3 | 13 | ORN | "△" NOT | C | 18 | GY | "mV" NOT |
| 4 | 14 | YEL | "mV" MODE | D | NC | | |
| 5 | NC | | | E | J1201-7 | JUMPER | "▽" NOT |
| 6 | J1201-3 | JUMPER | "△" NOT | F | 17 | VIO | DP1 |
| 7 | 12 | RED | "▽" NOT | H | 16 | BLU | DP2 |
| 8 | NC | | | J | 15 | GRN | DP3 |
| 9 | 57 | WHT/VIO | GND | K | NC | | |
| 10 | 37 | WHT/BLK/VIO | ENCODE HOLD | L | 26 | WHT/BLU | +15V |
| 11 | NC | | | M | 28 | WHT/GY | −15V |
| 12 | 50 | BLK | GND | N | J1201-16 | JUMPER | SIGNAL LOW |
| 13 | J1201-N | JUMPER | | P | 32 | WHT/BLK/RED | SIGNAL HIGH |
| 14 | NC | | | R | NC | | |
| 15 | NC | | | S | 53 | WHT/ORN | ENCODE TRIG |
| 16 | J1201-N | JUMPER | GND | T | 27 | GRN/YEL | GND |
| 17 | J1201-U | JUMPER | +EDGEMETER | U | 34 | WHT/BLK/YEL | +EDGEMETER |
| 18 | NC | | DIGIT SELECT | V | NC | | BCD |
| 19 | 41 | BRN | 1 | W | 45 | GRN | 8 |
| 20 | 42 | RED | 2 | X | 46 | BLU | 4 |
| 21 | 43 | ORN | 3 | Y | 47 | VIO | 2 |
| 22 | 44 | YEL | 4 | Z | 48 | GY | 1 |

NOTES:
1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. [ ] EXTERNAL MARKINGS.
4. TEST CONDITIONS:
   RANGE 10mV
   SIGNAL 10mV
   ALL VOLTAGE READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED. ALL READINGS NOMINAL.
5. LAST NUMBERS USED:
   R185, C121
   R401
6. NUMBERS NOT USED:
   R101, R104 THRU R135, R179, R180
   C101 THRU C111
   Q101, 102, 104, 105, 107 THRU 121.
   CR101 THRU CR106.

Figure 6-2. Master Board Schematic Diagram (E831320A)




830612

Parts-Location Diagram (C830612B)

NOTES:

1. RESISTANCE VALUES IN OHMS.
2. SIGNAL PATH ——
3. FEEDBACK PATH ——
4. ▭ EXTERNAL MARKINGS
5. LAST NUMBER USED:
   R365 C303 Q339 CR308

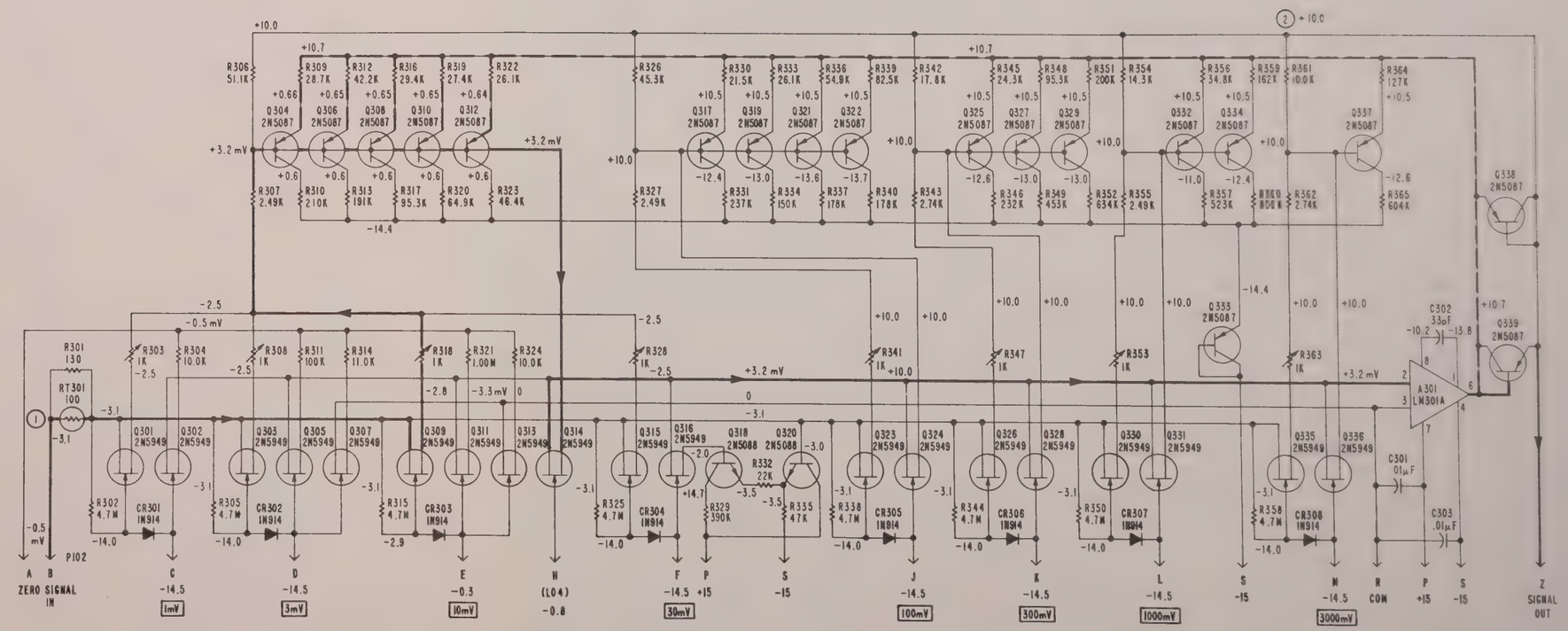
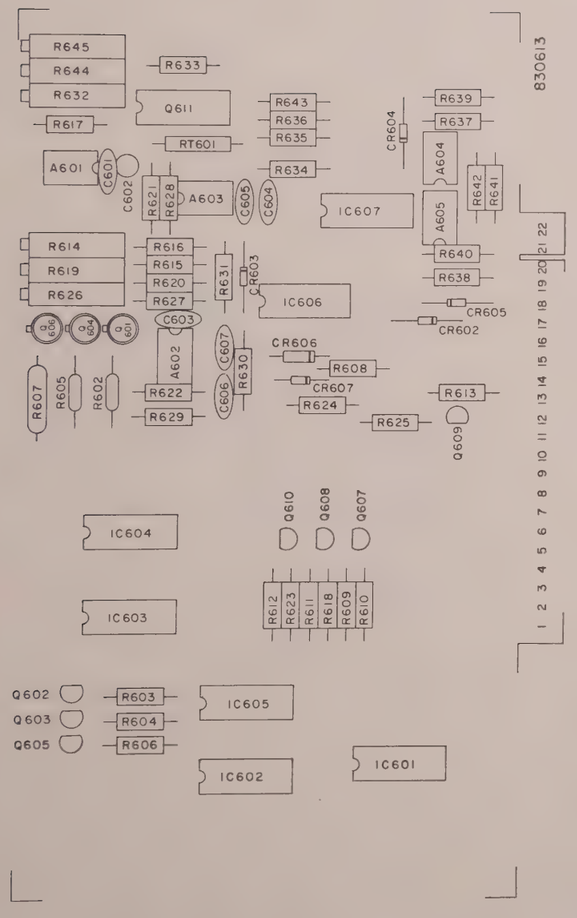



Figure 6-3. Shaping Amplifier Schematic Diagram (D830456P, Sheet 3 of 3)




Parts-Location Diagram (C830613C)

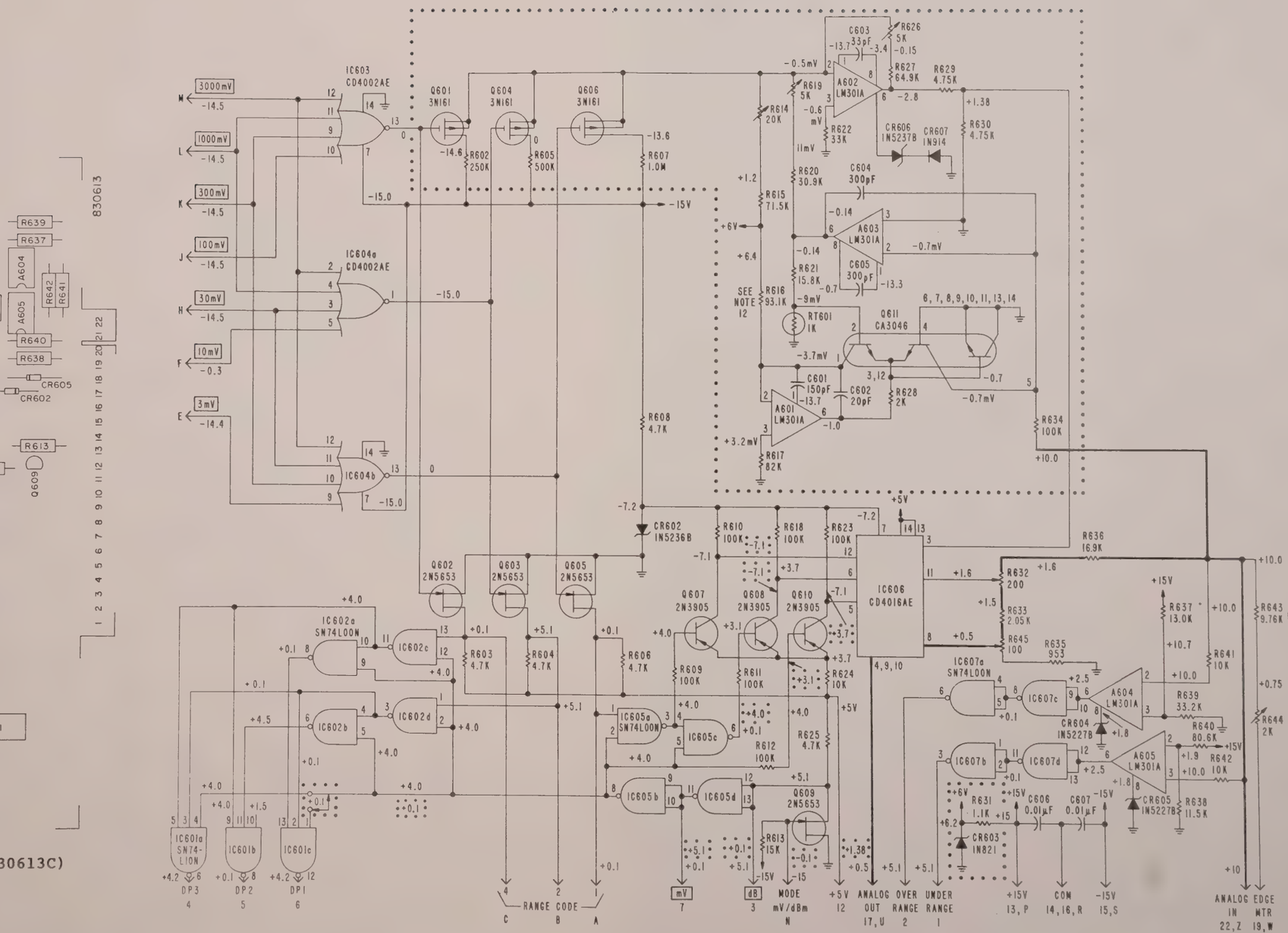
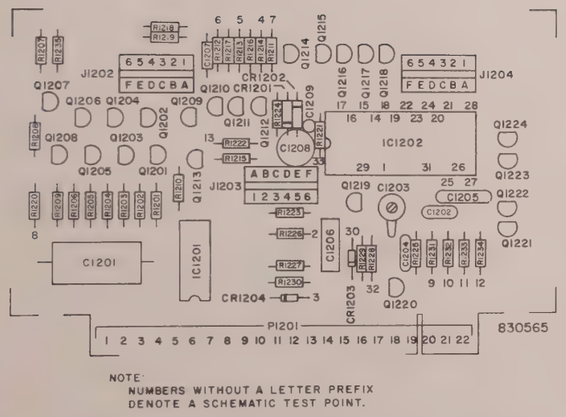
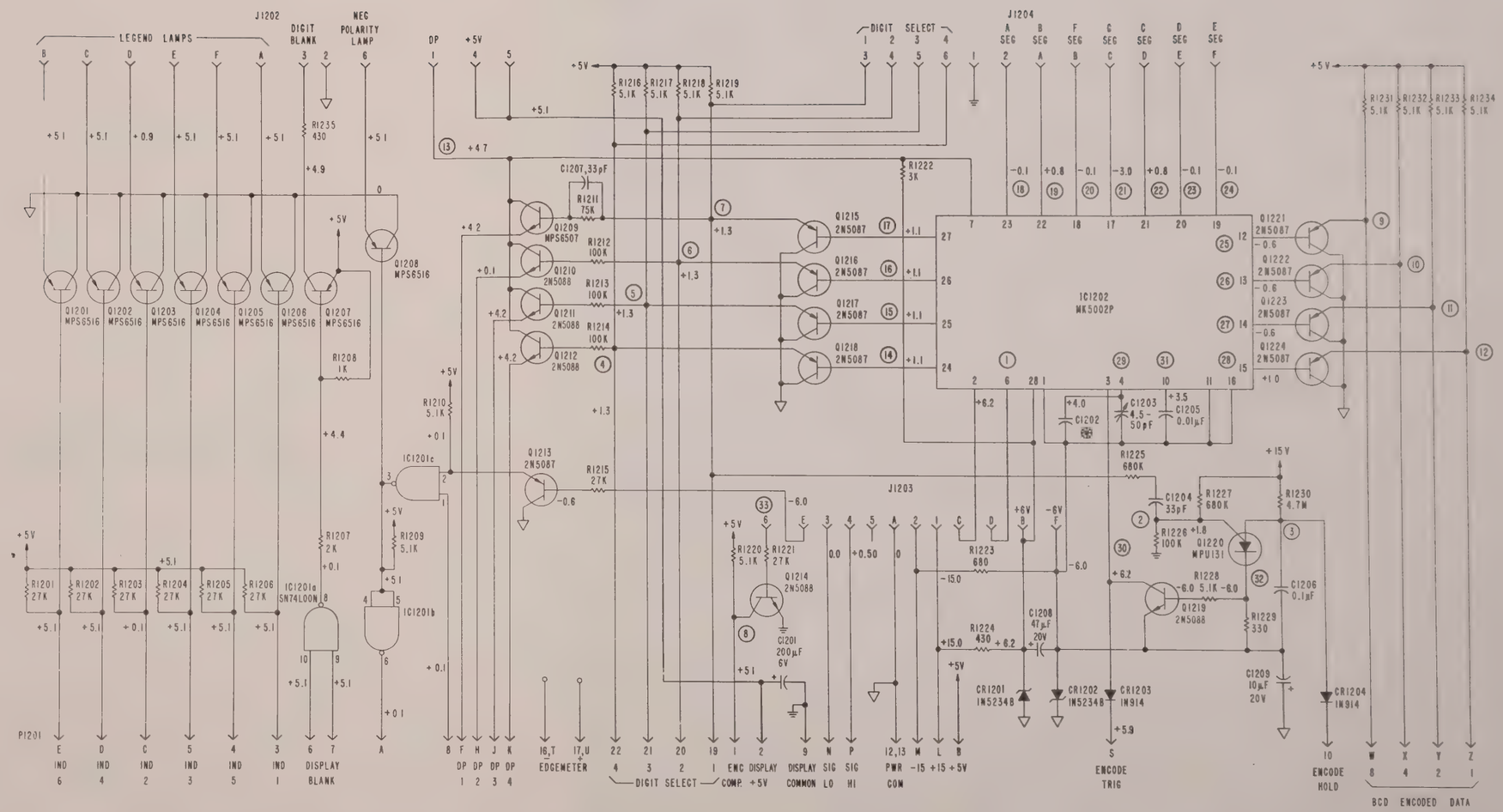


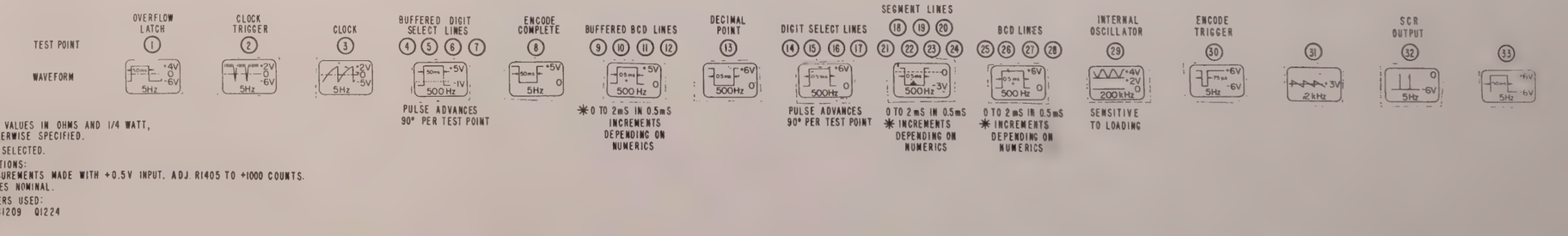

Figure 6-4. Digital-Control Board Schematic Diagram (D830581G, Sheet 2 of 3)




NOTE:
NUMBERS WITHOUT A LETTER PREFIX DENOTE A SCHEMATIC TEST POINT.

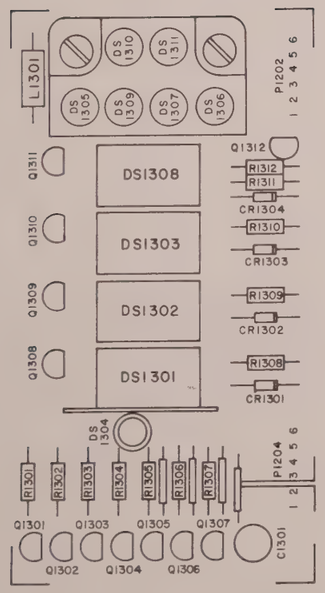
**Parts-Location Diagram (B830565F)**



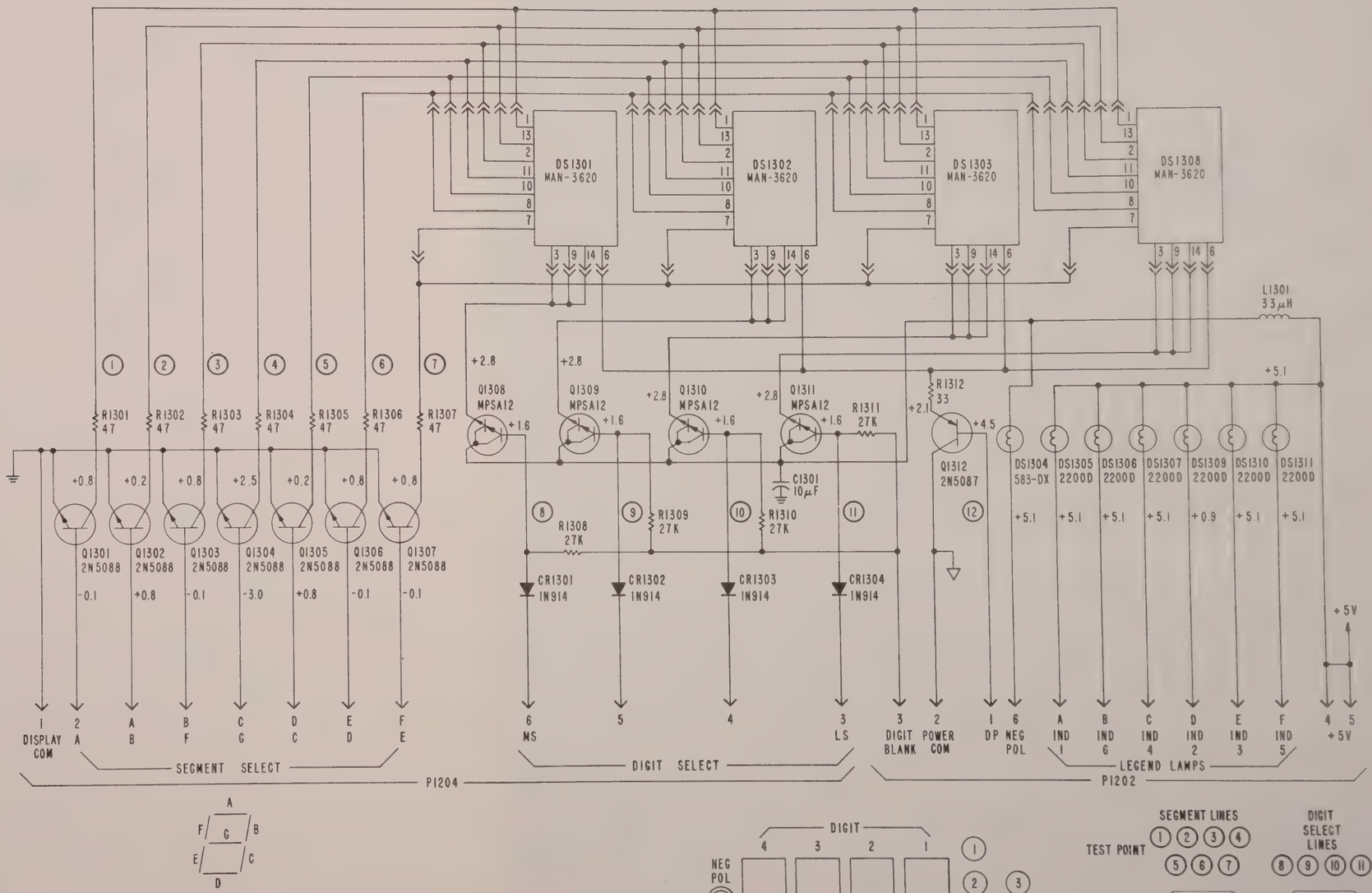




NOTES:
1. RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
2. ⊛ FACTORY SELECTED.
3. TEST CONDITIONS:
   ALL MEASUREMENTS MADE WITH +0.5V INPUT. ADJ. R1405 TO +1000 COUNTS.
   ALL VALUES NOMINAL.
4. LAST NUMBERS USED:
   R1235 C1209 Q1224
5. ⏚ COMMON

**Figure 6-5. Counter Board Schematic Diagram (E830546H, Sheet 1 of 3)**

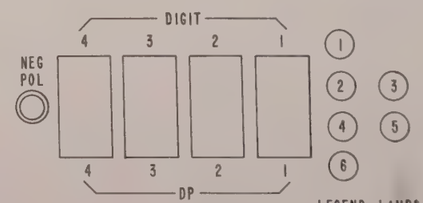


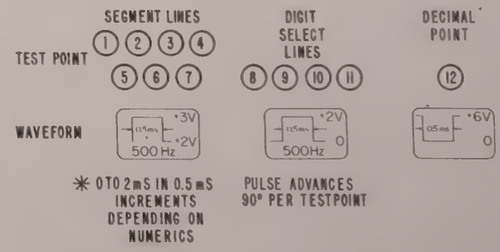

Parts-Location Diagram (B830566D)







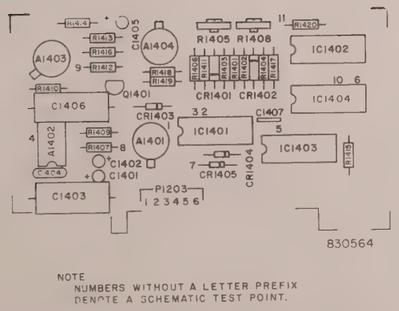



NOTES:

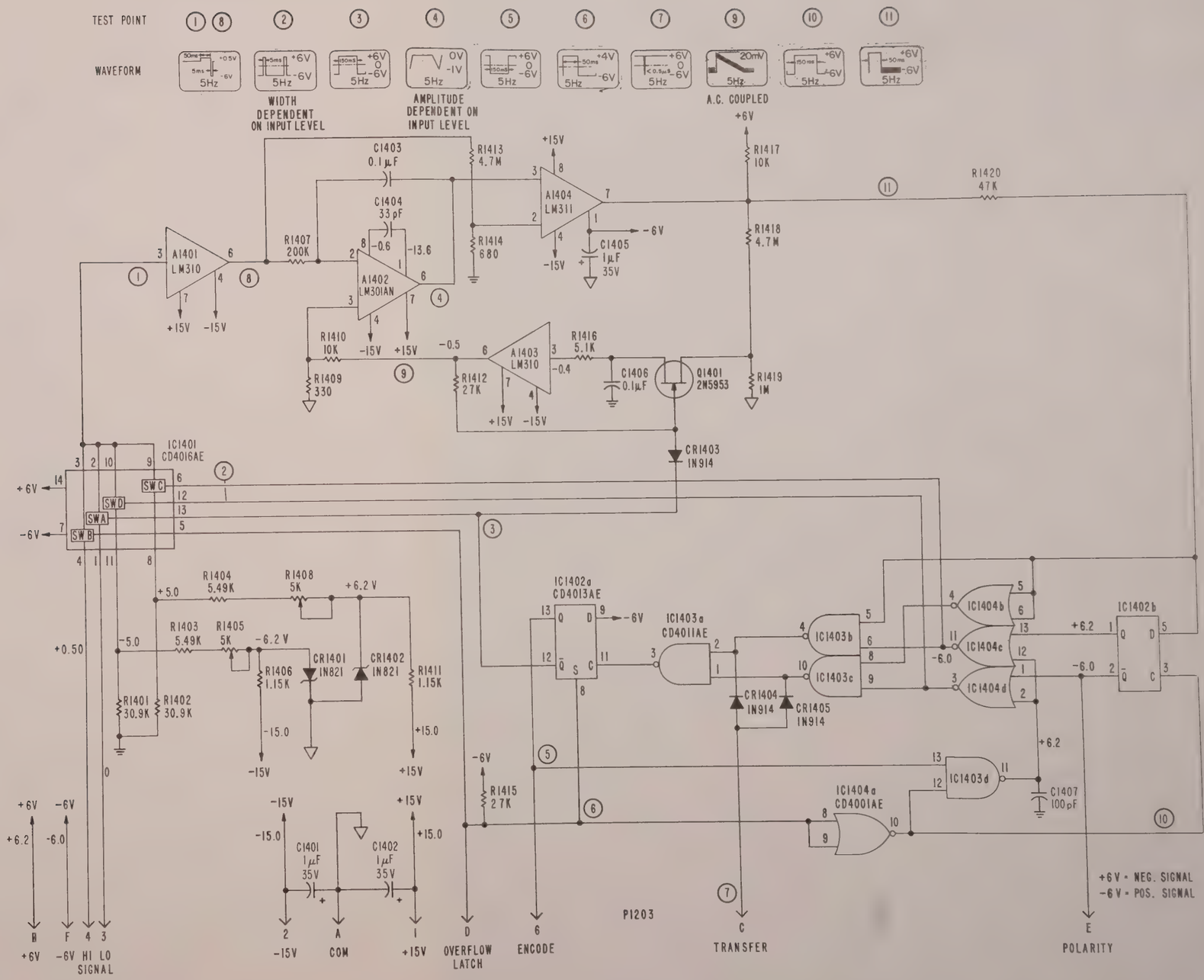
1. RESISTANCE VALUES IN OHMS AND 1/4WATT, UNLESS OTHERWISE SPECIFIED.
2. LAST NUMBERS USED:
   R1312, Q1312, DS1311, CR1304
3. TEST CONDITIONS:
   ALL MEASUREMENTS WITH 0.5Vdc INPUT (1000 COUNTS).
   ALL VALUES NOMINAL

Figure 6-6. Display Board Schematic Diagram (D830546J, Sheet 2 of 3)



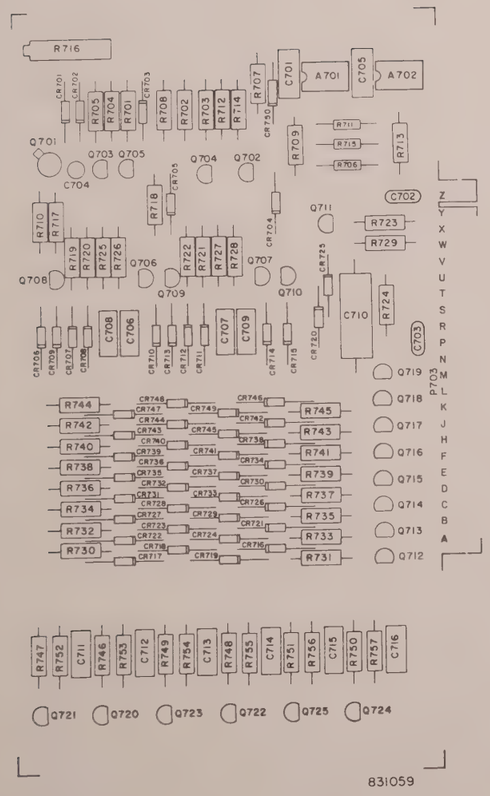

NOTE
NUMBERS WITHOUT A LETTER PREFIX DENOTE A SCHEMATIC TEST POINT.

Parts-Location Diagram (B830564F)

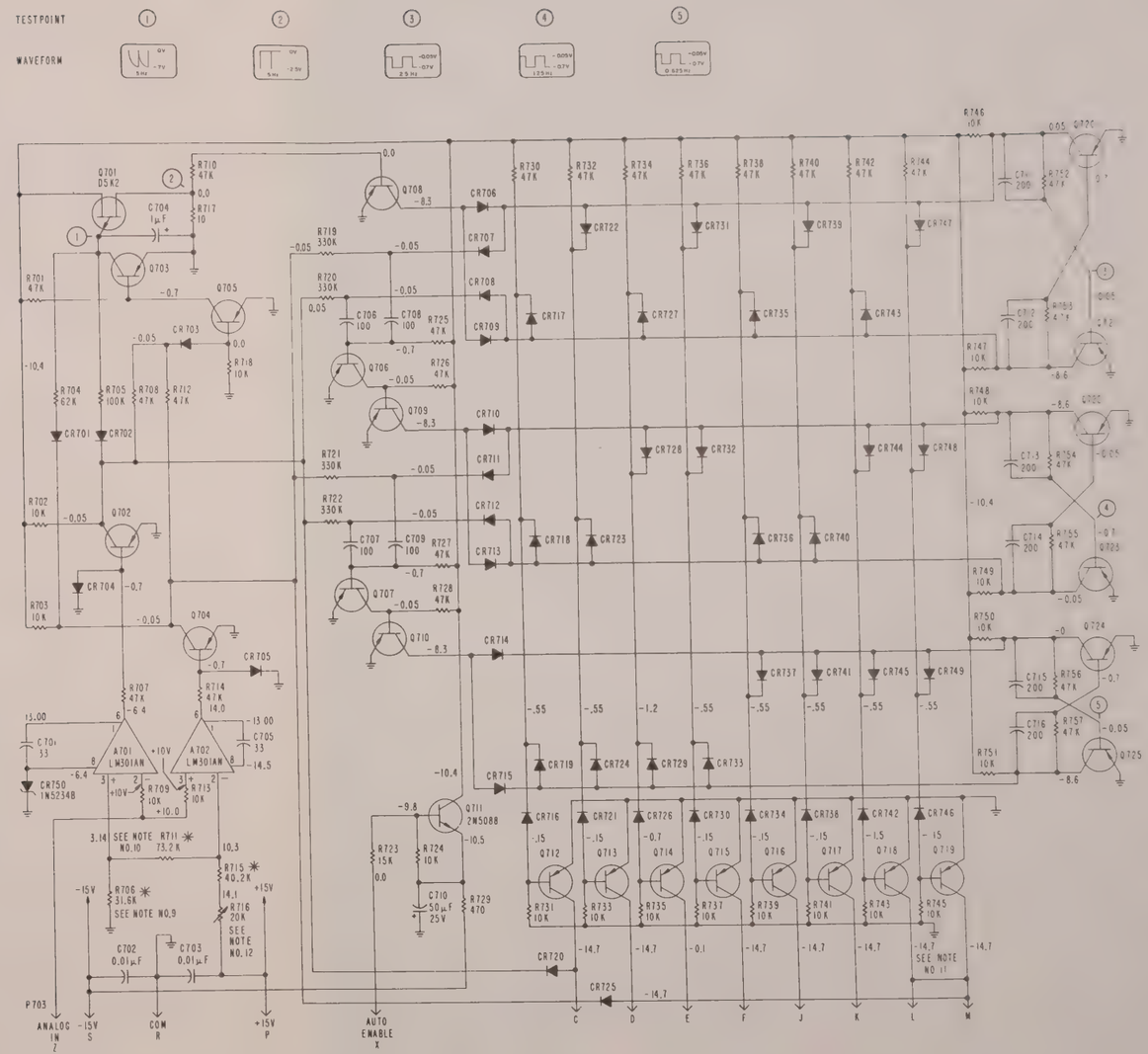



NOTES:
1. RESISTANCE VALUES IN OHMS.
2.
3. TEST CONDITIONS:
ALL MEASUREMENTS MADE WITH +0.5 Vdc INPUT (1000 COUNTS).
ALL VALUES NOMINAL.
4. LAST NUMBERS USED:
R1420 C1407
5. COMMON

Figure 6-7. A-D Converter Board Schematic Diagram (D830546F, Sheet 3 of 3)




Parts-Location Diagram (C831059B)




NOTES:

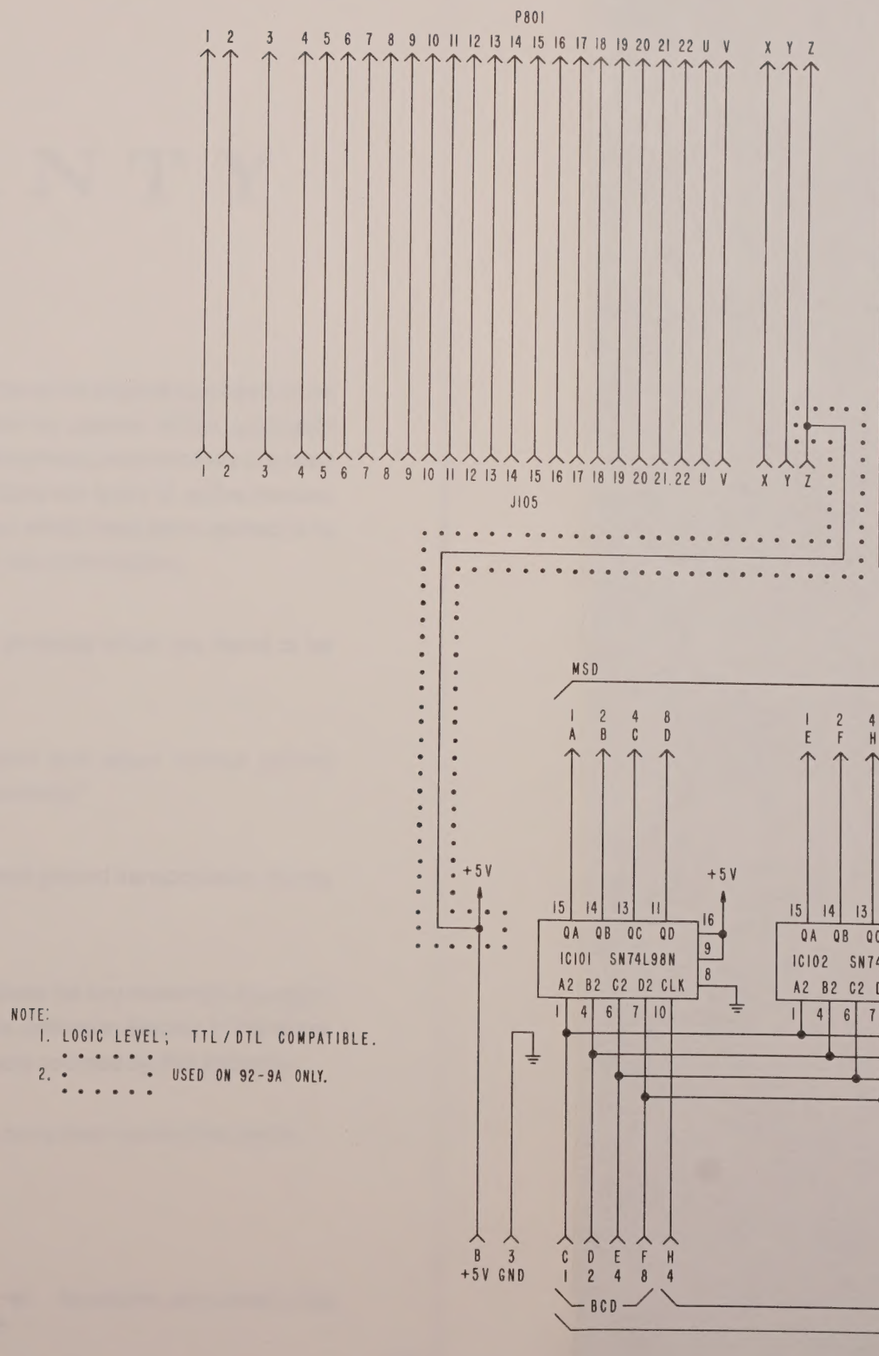
1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTORS.
4. ALL TRANSISTORS TO BE TYPE MPS6516, UNLESS OTHERWISE SPECIFIED.
5. ALL DIODES TO BE TYPE 1N914, UNLESS OTHERWISE SPECIFIED.
6. WAVESHAPES OCCUR DURING RANGE CHANGE ONLY.
7. ALL VOLTAGE READINGS NOMINAL VOLTS.
8. LAST NUMBERS USED:
   R757 C716 Q725 CR750
9. ON MODELS 42BD-01 AND 42CD-01 THIS VALUE IS 9.53 K.
10. ON MODELS 42BD-01 AND 42CD-01 THIS VALUE IS 95.3K.
11. THIS CONNECTION FOR 42BD-01 AND 42CD-01.
12. ON MODELS 42BD-01 AND 42CD-01 THIS VALUE IS 50K.
13. TEST CONDITIONS:

| | 92BD | 42BD | 42CD |
|---|---|---|---|
| RANGE: | 10mV | 1μW | 10μW |
| INPUT: | 10mV | 1μW | 10μW |

FULL SCALE MARKINGS FOR P703

| P703 | 92BD | 42BD | 42CD |
|---|---|---|---|
| C | 1mV | 10nW | 100nW |
| D | 3mV | 100nW | 1μW |
| E | 10mV | 1μW | 10μW |
| F | 30mV | 10μW | 100μW |
| J | 100 mV | 100μW | 1mW |
| K | 300mV | 1mW | 10mW |
| L | 1000 mV | 10mW | 100mW |
| M | 3000 mV | — | — |

Figure 6-8. AutoRange Board Schematic Diagram (E830483F)




NOTE:
1. LOGIC LEVEL; TTL/DTL COMPATIBLE.
2. USED ON 92-9A ONLY.

PIN ASSIGNMENTS

| P801 | | | | | | P801 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 42BD | 42CD | 92BD | 72BD | | 42BD | 42CD | 92BD | 72BD | |
| 1 | | | | HI TERM BIAS ± | A | 1 | | | | |
| 2 | - dBm | | | LO TERM BIAS ± | B | 2 | | | | MSD |
| 3 | LOGIC GROUND | | | | C | 4 | | | | |
| 4 | ANALOG OUTPUT | | | | D | 8 | | | | |
| 5 | COMMON | | | | E | 1 | | | | |
| 6 | AUTO ENABLE | | | | F | 2 | | | | |
| 7 | MANUAL DISABLE | | | | H | 4 | | | | BCD |
| 8 | dBm ENABLE | | | | J | 8 | | | | ENCODED |
| 9 | | | 3000 mV | | K | 1 | | | | DATA |
| 10 | 10 mW | 100 mW | 1000 mV | 2000 pF | L | 2 | | | | |
| 11 | 1 mW | 10 mW | 300 mV | | M | 4 | | | | |
| 12 | 100 µW | 1 mW | 100 mV | 200 pF | N | 8 | | | | |
| 13 | 10 µW | 100 µW | 30 mV | | P | 1 | | | | |
| 14 | 1 µW | 10 µW | 10 mV | 20 pF | R | 2 | | | | LSD |
| 15 | 100 nW | 1 nW | 3 mV | | S | 4 | | | | |
| 16 | 10 nW | 100 nW | 1 mV | 2 pF | T | 8 | | | | |
| 17 | 4 | | | 2 | U | | | | | |
| 18 | 2 | RANGE CODE | | 1 | V | TRIGGER | | | | |
| 19 | 1 | | | | W | COMPLETE | | | | ENCODE |
| 20 | UNDERRANGE "NOT" | | | | X | HOLD | | | | |
| 21 | OVERRANGE "NOT" | | | | Y | | | | | |
| 22 | PWR MODE | | mV MODE | POLARITY | Z | | | | | |

Figure 6-9. Serial-Parallel BCD Converter Schematic Diagram (D830650C)

# WARRANTY

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return normal ground transportation during the first three months of this warranty.*

There will be no charge for parts, labor, or return normal ground transportation during the fourth through twelfth month of this warranty.*

Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

*For *overseas shipments,* there will be no charge for Air Freight during these specified time periods.

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